# JOURNAL OF THE A·I·E·E·

JUNE 1930

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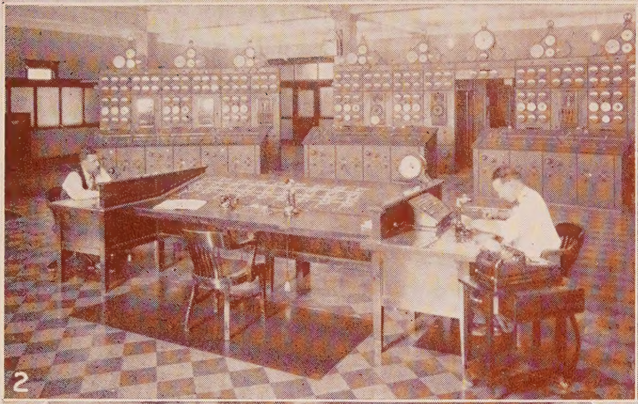
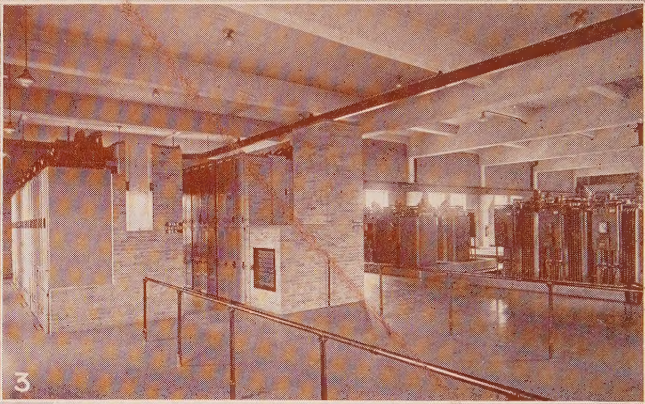
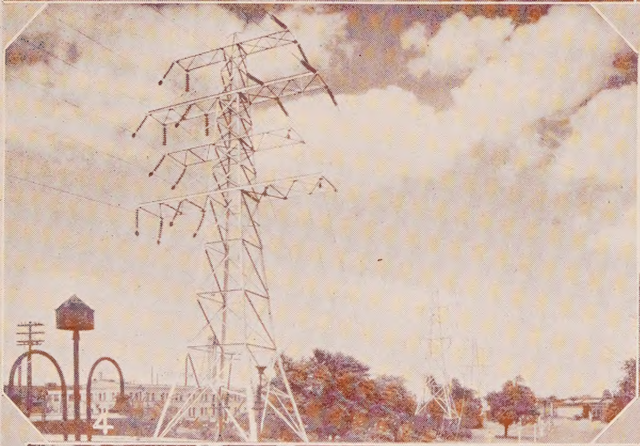
PUBLISHED MONTHLY BY THE
AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
33 WEST 39TH ST· NEW YORK CITY

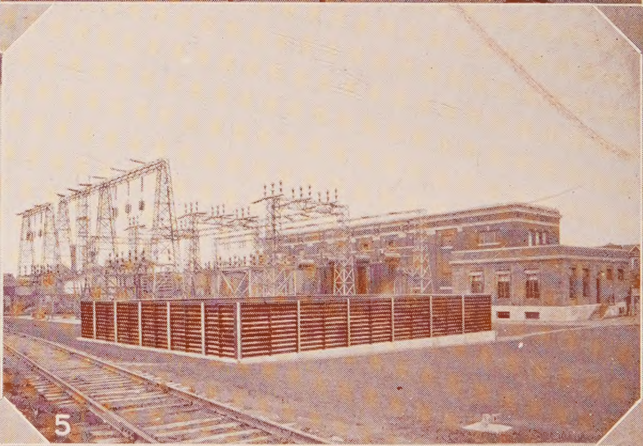
SUMMER CONVENTION, TORONTO, JUNE 23-27

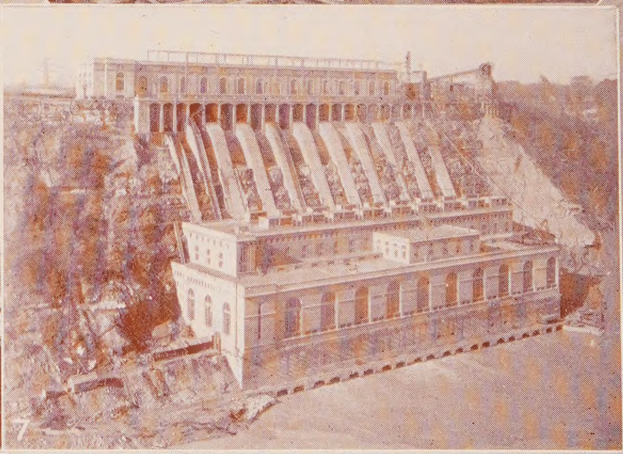
# Views in the Neighborhood of the Summer Convention











1. Sky Line, City of Toronto
2. Control Desk, Queenston Power House
3. Interior View of Parkdale Substation, Toronto Hydro-Electric System
4. Four-Circuit 110-Kv. Line Entering Toronto from Niagara Falls
5. Wiltshire Avenue Station. General View from North East
6. Wiltshire A and B Supervisory Controlled Stations
7. Queenston Power House, Hydro-Electric Power Commission of Ontario

# JOURNAL of the A. I. E. E.

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33 West 39th Street, New York
**PUBLICATION COMMITTEE**
W. S. Gorsuch, *Chairman*, H. P. Charlesworth, F. L. Hutchinson, A. E. Knowlton, E. B. Meyer

George R. Metcalf, *Editor*

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Vol. XLIX JUNE 1930 Number 6

## TABLE OF CONTENTS

### Papers, Discussion, Reports, Etc.



### Institute and Related Activities



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(The Journal of the A. I. E. E. is indexed in Industrial Arts Index.)

# MEETINGS

of the

## American Institute of Electrical Engineers

SUMMER CONVENTION, Toronto, Ontario, Canada, June 23-27, 1930

PACIFIC COAST CONVENTION, Portland, Oregon, September 2-5, 1930

MIDDLE EASTERN DISTRICT MEETING, No. 2, Philadelphia, Pa., October 13-15, 1930

SOUTHERN DISTRICT MEETING, No. 4, Louisville, Kentucky, November 19-22, 1930

### MEETINGS OF OTHER SOCIETIES

Spring Meeting American Society of Mechanical Engineers, Detroit, June 9-12. (Calvin W. Rice, Secretary, 29 West 39th St., New York, N. Y.)

Canadian Electrical Association, Manor Richelieu, Murray Bay, Que., June 11-13. (M. H. Lyster, 405 Power Building, Montreal)

National Electric Light Association

Pacific Coast Division, San Francisco, Calif., June 16-20. (S. H. Taylor, 447 Sutter St., San Francisco)

San Francisco, June 16-20. (A. J. Marshall, 420 Lexington Avenue, New York)

American Physical Society, Ithaca, New York, June 19-21, 1930

American Electric Railway Association, San Francisco, June 21-26. (Guy C. Hecker, 292 Madison Ave., New York)

American Society for Testing Materials, Haddon Hall, Atlantic City, N. J., June 23-27. (C. L. Warwick, 1315 Spruce St., Philadelphia)

# JOURNAL OF THE A. I. E. E.

DEVOTED TO THE ADVANCEMENT OF THE THEORY AND PRACTISE OF ELECTRICAL ENGINEERING AND THE ALLIED ARTS AND SCIENCES

*The Institute is not responsible for the statements and opinions given in the papers and discussions published herein. These are the views of individuals to whom they are credited and are not binding on the membership as a whole.*

Vol. XLIX JUNE, 1930 Number 6

*A Message From the President*

## The Peregrinations of the President

SINCE August 1, 1929, and before this appears in the printed page, there has been an attempt to bring the administration of the Institute and its membership into as close personal contact as possible by visits of its president to many centers of Institute activity. These visits can only be enumerated in the following order, in which they occurred, and do not include visits to headquarters, directors' meetings, and Institute work and contacts in other connections.

Winnipeg, Regina, Vancouver, Seattle, Spokane, Portland, San Francisco, Santa Monica, Salt Lake City, Denver, Omaha, Des Moines, Kansas City, St. Louis, Sharon, Syracuse, Fort Wayne, Milwaukee, Minneapolis, Madison, Chicago, Urbana, Indianapolis, Lafayette, Pittsburgh, Buffalo, Toledo, Erie, Cincinnati, Louisville, Memphis, Oklahoma City, Dallas, Texas A. & M., Houston, Austin, San Antonio, Monterey, Mexico City, Havana, New Orleans, Birmingham, Atlanta, Raleigh, Norfolk, Washington, Baltimore, Philadelphia, Rochester, Ithaca, Springfield, Detroit, Cleveland, Akron, Columbus, Montreal and Toronto have been visited. In other words, practically every Section of the Institute has been visited, with the exception of a small group in District No. 1 that had recently been visited, and of those, Boston, Lynn, Providence, Worcester, Springfield, Connecticut, and Pittsfield united at Worcester on April 25th for an experimental demonstration of high voltages. With national and district conventions, a few branch meetings, directors' meetings, functions of sister professional societies, etc., this has involved a total of about seventy-five meetings attended in the interests of the Institute during the course of the year.

The unusual opportunity which has thus been afforded the president has been greatly appreciated by him and has been studied in the hope of benefit to the Institute. The pleasant personal greetings and expressions to him, as representing the Institute, of interest in its problems and loyalty to its purposes has been an inspiration. There have been many and evident instances that whatever touches the heart of the life and future of the Institute at the same instant touches the heart and interest of the members.

In general, there has been keen interest in all sections of the country in the important and vital problems before the Institute. The problems of the Publication Committee, particularly as affecting the JOURNAL, the Standards Committee, the possibility of arranging on a basis most economical of time, for distinguished speakers for all sections, stimulus and help to the younger membership, all questions looking to the best good of the future life of the Institute, are live questions in the minds of the general membership and will be evidenced in the discussions of the representatives of the Sections at the Conferences of Officers and Section Delegates at Toronto the last of this month.

Harold B. Smith
*President.*

## Some Leaders of the A. I. E. E.

Frank William Peek, Jr. joined the Institute as an Associate in 1907. He has always taken an active part in Institute affairs and in 1925 was transferred to the grade of Fellow. As Chief Engineer of the Transformer Engineering Department of the General Electric Company at Pittsfield, Mass., and in view of the fact that he is a native of California, (born at Mokelumne Hill and graduated from Leland Stanford University in 1905) it is fitting that he should have made his greatest contributions to science in the discovery or laws relating to corona as applied to transmission lines. It was in California, from the Bay Counties plant equipped with Stanley apparatus, that power was first, in the early nineties, transmitted at 60,000 volts over a distance of 140 miles; more recently 220,000-volt lines were placed in service in California. In truth, Mr. Peek's first electrical work was done at the Electra plant of the Pacific Gas & Electric Company, California, during college vacations.

California and its people do big things, and in 1923, when the million-volt tests were first produced in General Electric's Pittsfield Laboratory, it was Mr. Peek who directed the experiments. In the Pittsfield laboratory, 5,000,000 volts are now available for research work.

Mr. Peek entered the General Electric Company on the test in Schenectady in 1905, and was put in charge of "Special Test" (on engineering research) in 1906. From 1907 to 1909 he worked on general practical problems and transmission work in the Power and Mining Engineering Department. At this time he started his research in corona, which prepared him for his work in high-voltage transmission.

During the summers of 1907 and 1908 Mr. Peek made a special study of lightning and its effects on transmission lines in the mountains of Colorado. From 1909 to 1910 he investigated the problems connected with transmission at 250 kv. It was at this time that he established the first laws of corona and put them in form for practical application to transmission problems. He also investigated line regulation and the grading of insulators.

When in 1909 the General Electric Company's Consulting Engineering Department was formed by Dr. Charles P. Steinmetz, Mr. Peek was one of the first to join it. During the next year he lectured at Union College, and since then, he has done general consulting work on practical and theoretical engineering problems and research work. In 1911, for work done in connection with high-voltage transmission, he received a degree of Master of Electrical Engineering from Union College.

In 1916 Mr. Peek was transferred to the Pittsfield Works of the General Electric Company to take charge of the High-Voltage Laboratory. Probably his best known work, in research were the formation and establishment of laws regarding corona, the laws of dielectric time lag, the investigation of lightning phenomena and their effects on high-voltage transmission, the study of dielectric phenomena, line insulations and the problems connected with the transmission of high-voltage currents.

Mr. Peek has prepared many valuable and authoritative papers concerning the laws of corona, measurements of high voltages, lightning and transmission voltages, electrical strength of air, oil and solid insulation, high voltage phenomena which have been read before the leading scientific and engineering societies of the country; also practical papers on high-voltage engineer-problems, transmission line calculations, etc. He has contributed over 200 articles to the A. I. E. E., the American Society of Civil Engineers, *General Electric Review*, *Electrical World*, and to many foreign papers.

Numerous inventions relating to high-voltage insulations, transmission lines, lightning arresters, electrochemical subjects, etc., are credited to Mr. Peek.

"Dielectric Phenomena in High-Voltage Engineering," written by Mr. Peek, is used both as a reference and textbook in all the leading colleges and libraries of the world, including Japan, France, Belgium and England.

For several years he was the Chairman of the Electrophysics and Research Committees and a member of the Meetings and Papers Committee of the Institute. He is a member of the American Association for the Advancement of Science, the Sigma Xi Scientific Honor Society and a Fellow in the American Physical Society. He is also a member of the Franklin Institute.

Mr. Peek has always been interested in pure research work, applying the results to practical problems. His position at present is Consulting and Research Engineer, Head of the General Transformer Engineering Department, and of the High-Voltage Engineering Laboratory of the General Electric Company at Pittsfield, Mass.

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Twice each day, according to Professor Fernando Sanford, insulated objects near the earth's surface change their electric charge about 200 volts—positive in daylight and negative at night. This effect is presumed to be caused by the interaction of electric charges on the sun and on the earth. Perhaps this explains terrestrial magnetism and perhaps it is the motivating force in many physiological and biological phenomena. Human beings sleep better at night, some plants close their flowers at night, some animals sleep only at night. Might not the effect of these electric charges on insulated structures explain this phenomena?

Then, again, at the Academy of Science meeting it was claimed that electricity is responsible for memory. An electric charge creates a permanent plate in the brain cell structure corresponding to a thought or emotion, and this becomes a memory phenomena when a similar charge sensitizes the plate at a later time. If scientific facts and speculative conclusions from experimental data continue to be brought forth we shall soon call electricity the Alpha and Omega of creation. —*Electrical World.*

Abridgment of

# Centralized Control of System Operation

BY JAMES T. LAWSON*

Member, A. I. E. E.

***Synopsis.**—This paper considers the application of centralized control of system operation of the Public Service Electric and Gas Company in New Jersey. A brief history of events leading to the installation of supervisory system operation is given, with a detailed description of the apparatus and the methods used to carry out the indications, together with a statement as to what is being accomplished in improving the service.*

* * * * *

IN the early days of the generation of electrical energy, there was little need of load dispatchers or system operators. Then each power station supplied its own local territory, usually at 250 or 500 volts, direct current or 1000 or 2400 volts, alternating current. The operating man in charge of the power station or distribution system could direct the handling of apparatus and feeders without any trouble. Power stations were not run in multiple and each one could be operated in a manner best suited to it.

Gradually, as consolidation was effected and territories enlarged, several plants were tied together, and in time, voltages were raised. The method of allowing superintendents or chief engineers to operate the distribution systems and the stations according to their own individual ideas led to confusing, inefficient operation, and had to be discontinued.

This forced in a group of men, who would be available at all hours to guard the operation of the system as a whole.

Such a scheme was first started in our system in 1900, to handle d-c. railway feeders. At this time, the operator did the work as a side line to other duties and his entire equipment consisted of a small plug board, somewhat like a cribbage board, with the names of the stations and substations lettered on the left-hand side and the feeder numbers across the top. A series of holes was drilled across the board to match. By placing pegs in the proper holes, it was possible to keep track of the railway feeder operation.

In 1906 parallel operation of the stations became necessary and centralized control of system operation imperative and the first load dispatching office was then started in our Marion Station, Jersey City.

The operating board consisted of a wooden drawing board, an elaboration on the original plug board about 6 ft. by 12 ft., painted white and marked with single-wire diagrams of the transmission lines and station and substation busses, and showing symbolically the main apparatus in each station and substation. The diagrams of transmission lines, apparatus, and busses were placed on the board by using gummed paper cut in narrow strips, and gummed letters and numbers.

Wooden plugs, colored red and white, were used, placed in holes drilled in the board. But few private telephone lines were in use.

In 1909 and 1914, load dispatching systems were established in the Central and Southern Divisions. At this time the three divisions were not electrically connected and we thus had four load dispatching offices. The work increased rapidly, and as the system expanded

Fig. 1—Manually Controlled Load Dispatcher's Pilot Board

and the divisions were tied together, the future seemed to point to the need of one central load dispatching office to control the operation of the entire system as a unit, not only within itself but in its relation to connections which might be effected with other companies.

Accordingly, plans were made to consolidate three of the offices and move them into a centralized office at Newark; this was accomplished in 1926.

A load dispatcher must be familiar with every operating detail, and an accurate and up-to-the-minute diagram of the bus layout of each station and substation is necessary. The load dispatcher's diagram of busses, and substation and generating station apparatus, is known as a "pilot board." Our first pilot boards were made of wood, using gummed paper for the diagrams and small wooden plugs inserted by hand in holes drilled

*Assistant to General Superintendent of Generation, Public Service Electric and Gas Company, Newark, New Jersey.

*Presented at the Summer Convention of the A. I. E. E., Toronto, Ont., Canada, June 23-27, 1930. Complete copy upon request.*

in the board to show the switch and apparatus positions. These were changed to a type of board using instead of plugs, a scheme of small colored lights manually controlled by the load dispatcher from his desk. (See Fig. 1.)

These types of pilot boards are accurate only in so far as the plugs or lights are changed in response to telephone messages, or orders given or received. Therefore they are not always an accurate visual record of the system. Time is lost in waiting for each station or substation operator to report switch positions and switch movements, especially in times of stress and trouble.

A board which automatically shows the position and movement of the switches not only serves as a diagrammatic record but also enables the load dispatcher to follow the switch operations as he directs them, and, more important in times of trouble, gives him an instantaneous indication of system conditions.

From these indications, without waiting for reports from generating station and substation operators, he is in a position to act immediately toward restoring service and maintaining normal system conditions.

Accordingly, when it was decided to centralize the load dispatchers' office, an automatic pilot board was considered; but the cost for the entire territory was so great that it was decided to have only automatic indication from the stations and substations in the vicinity of Newark, the remainder to be manually controlled.

There are 42 distributors in all, located in 21 substations and in Marion, Kearny, and Essex generating stations. Some of the smaller substations do not have distributors, the positions of the oil circuit breakers being indicated over direct-wire connections.

Each distributor will automatically indicate from 50 to 100 switches, depending on whether or not supervisory control of the switches is desired in conjunction with automatic indication. Therefore, one distributor will usually take care of a substation while two or more are needed for the generating stations.

The positions of the oil circuit breakers in substations not equipped with automatic indicating apparatus are shown by means of small control switches, manually operated, that light red and green lamps, the information for keeping these indications correct being obtained by the load dispatcher by telephone from the substation operators.

The load dispatcher's office consists of two rooms. The office proper contains the remote metering panels, telephone switchboards, pilot board, etc.; the second room contains the apparatus, batteries, motor generator sets, etc., for obtaining automatic indication of the switches in the substations and power stations.

Red and green lights indicate the closed and open positions of oil circuit breakers, and white lights with a horizontal or vertical black line across the lamp, the closed or open positions of disconnecting switches. A group of three lights is used for an oil circuit breaker, (the red and green referred to above), and in addition, a clear white light, the function of which is to indicate that the oil circuit breaker has changed its position. This white light is extinguished by a small push-pull, single-pole double-throw switch, thus compelling the load dispatcher to acknowledge the operation of the oil circuit breaker and also giving him notice that an oil circuit breaker has operated, since under normal operation the board is operated with all white lights unlighted. In the arrangement used, the white light is on top, the red and green lights directly below in the order given. Underneath the green light, the oil circuit breaker designation is painted on the face of the board. So far as practicable, the various oil circuit breakers and disconnecting switches are shown in their correct positions relative to one another. While all oil circuit breakers in the transmission system are indicated, only

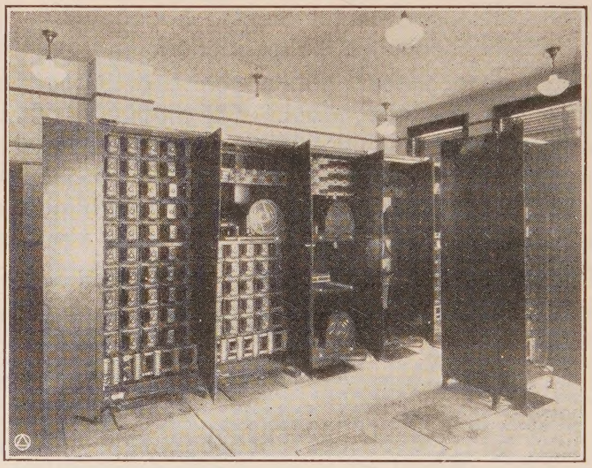

Fig. 3—Relay and Distributor Cabinets

such disconnecting switches as perform a switching function are shown. Disconnecting switches which serve only to isolate other apparatus from the system are not shown on the load dispatcher's board, since in most cases such isolating disconnecting switches are stick operated, so there is no simple means of obtaining automatic indication. The load dispatcher is supplied with simplified wiring diagrams of each station and substation, which show all such isolating switches as well as other necessary information not feasible to show on the indicating board.

Fig. 3 shows some of the relay and distributor cabinets. The cabinet at the left is a 100-relay cabinet, there being 50 relays on the reverse side of the cabinet. The second from the left is a combined distributor and relay cabinet. The third and fourth from the left show cabinets with a capacity of three distributors each, although the two middle distributors have been removed.

A general view of the front of the load dispatcher's board is shown in Fig. 6.

The Public Service Electric and Gas Company supplies the more populous sections of the State of New Jersey with electric light and power. That portion of the state served from the New York State line on the east to the Delaware River below Camden on the west is outlined on the map of the State of New Jersey, in Fig. 8. The territory is 110 mi. long and covers an area approximately of 1700 sq. mi. as compared with 8224 sq. mi. in the state. This area includes about 88 per cent of the population of the state, which exceeds

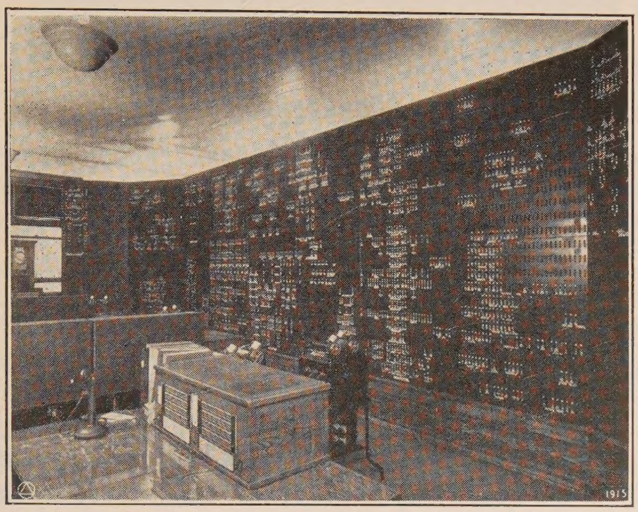

Fig. 6—Load Dispatcher's Pilot Board, Front View

3,500,000; electric meters, December 31, 1929, numbered 886,797. The portion of the territory directly supervised and operated from the Newark Terminal load dispatchers' office is shown in the clear area. The stations and substations which have automatic indication on the load dispatchers' board are located within or adjacent to the City of Newark. Indications from the other stations and substations are controlled by manually operated miniature switches manipulated by the load dispatchers from information obtained by telephone.

The entire Public Service territory is supervised from the Newark load dispatching center, although the southern area, or shaded portion of the map, is operated directly from a load dispatching office at Burlington.

In the entire system, there are 131 Public Service and industrial substations, nine switching stations, and five generating stations. Of this number, the Newark load dispatcher has direct supervision over and operates 87 substations, eight switching stations, and four generating stations, leaving 44 substations, one switching station, and one generating station in the Southern Zone.

It is difficult to estimate the value of a load dispatching system or the value of one type of load dispatching equipment over another; these, we believe, are matters of local importance and must be judged by the individual utility which may wish to employ the several methods. No doubt load dispatching can be, and is, handled with simple as well as elaborate equipment,—a matter of opinion. Our experience in using the simplest as compared with the elaborate leads us to believe that the automatic indicating equipment, backed up with accessory apparatus, gives the best results as regards safety, service, and economical handling of station load.

After an experience of three years with the automatic indication system, we have not changed our opinion.

With the completion of the 132-kv. transmission system and the existing and approaching interconnections with other companies, the advantage of centralized control of system operation to this company has become more apparent.

The 132-kv. transmission system has made it possible to schedule the loading of generating stations so as to obtain operating economy. These load schedules would

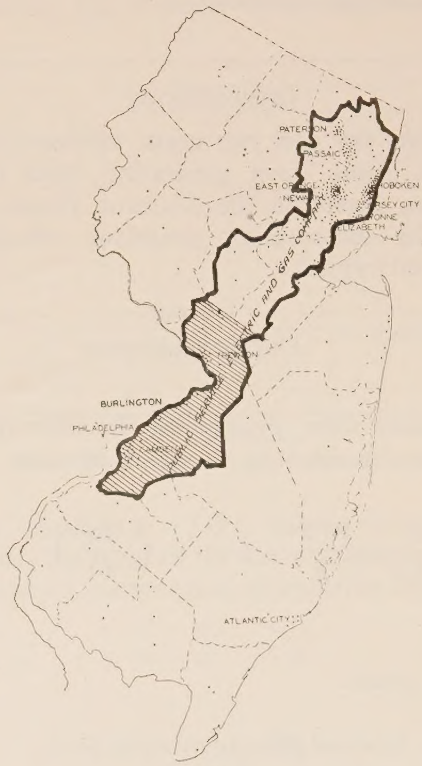


Fig. 8—Map of New Jersey showing the Territory of the Electric and Gas Company. The Unshaded Portion is Operated by Newark Load Dispatching Office

be almost impossible to follow effectively if the system were not controlled at a central point.

At the end of the current year, 1930, this company will be interconnected with three other companies, and there will be operating agreements with each, governing the interchange of power. This interchange will fall into several classes and each class will be regulated by different conditions and restrictions. It is evident that centralized control will be required to procure reliable

action, to take advantage of effecting economies, and to avoid penalties which might result from the lack of coordination.

During 1929, the load dispatchers issued a total of 238,986 operating orders in connection with switching changes; and of this total, only one operating mistake resulting in interruption to service is chargeable to the load dispatcher. This one interruption occurred at a time which caused no inconvenience to the customer; in fact, it was not noticed or reported. We feel justified therefore in having incurred the cost of installing and maintaining the automatic indicating system.

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Abridgment of

# Determination of Generator Speed and Retardation During Loss Measurements

BY O. E. CHARLTON* and W. D. KETCHUM*

Associate, A. I. E. E. Associate, A. I. E. E.

*Synopsis.—This paper describes an instrument which was developed to make graphic records of generator revolutions and time, as the generator slows down under the action of its losses during retardation tests. The construction of speed—time curves from the records thus obtained is outlined.*

*The principle of numerical differentiation is discussed and its application to the determination of the slope of the speed—time curve is pointed out.*

*A complete example illustrating the application of this principle is included in the unabridged paper.*

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## Introduction

During the past two years, efficiency tests have been made upon generating units in several hydro plants on the Alabama Power Company system. In determining generator efficiency, the fundamental formula

$$\text{Efficiency} = \frac{\text{Output}}{\text{Output plus losses}} \tag{1}$$

was used.

The losses were determined by the retardation method as described by J. Allen Johnson[1] from the equation

$$\frac{d\,E}{d\,t} = \frac{W\,R^2}{g} \,.\, 4\,\pi^2 \,.\, s \,.\, \left(\frac{d\,s}{d\,t}\right) \tag{2}$$

where

$\frac{d\,E}{d\,t}$ = power.

$W\,R^2$ = flywheel effect of rotating parts.

$g$ = acceleration of gravity.

$s$ = angular velocity of rotating parts.

$\frac{d\,s}{d\,t}$ = angular retardation of rotating parts.

The scope of this paper is limited to a description of the methods used in evaluating the speed ($s$) and the retardation $\left(\frac{d\,s}{d\,t}\right)$ for use in Equation (2).

*Southeastern Engg. Co., Birmingham, Ala.

1. For references see Bibliography.

*Presented at the North Eastern District Meeting of the A. I. E. E., Springfield, Mass., May 7-10, 1930. Complete copy upon request.*

## Measurement of Generator Speed

The precision of the results to be obtained from the retardation method depends primarily upon the accurate determination of the speed—time curve as the generator slows down, and upon the most exact determination possible of the slope of this curve at various points. Experience has shown that a tachometer and a stop watch do not provide the necessary degree of precision, particularly when the generator under test has relatively low $W\,R^2$ and consequently slows down rapidly. An attempt was therefore made to develop an instrument which would record these quantities accurately.

The ideal device for this purpose would be a recording instrument which would measure retardation directly, such as that suggested by V. Karapetoff.[2] No such instrument is on the market at the present time, however, and difficulties were encountered which prevented the construction of one for the tests.

As a substitute for this ideal instrument, a chronograph was constructed.

Essentially, it consists of a driving motor, an electrically operated tuning fork, and an electrically operated stylus. The record is made upon a strip of waxed paper which is unwound from a supply spool and passed under the stylus and tuning fork, continuing around the two driving rollers to the rewind spool. The tuning fork is electrically driven at 100 vibrations per second, while the stylus is energized through a contact on the generator shaft. Fig. 3 is a general view of this instrument, and Fig. 4 shows a typical record taken by it.

One refinement which has been found to contribute materially to the facility with which the records may be interpreted is the constant linear speed drive for the

paper. This is accomplished by driving the paper strip directly, through constant speed driving rolls, while a friction clutch automatically varies the speed of rotation of the rewind spool.

Between the tuning fork and the magnetic stylus there is located a spark-gap which is energized manually

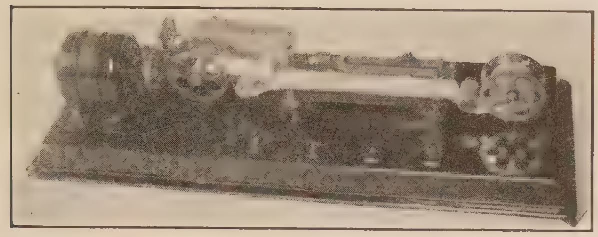

FIG. 3—IMPROVED CHRONOGRAPH

from a switch. The function of this gap is to designate on the chronogram the instant of taking readings on the instruments.

## SPEED—TIME CURVE

The data supplied by the chronogram are in the form of two graphic records, one of revolutions and one of time. In order to obtain the speed of the generator at any point, it is of course necessary to count the indications of each of these records over a period of time. Since the displacement between indications of successive revolutions is far greater than that between successive cycles made by the tuning fork, it is obviously much simpler, from the standpoint of interpolation, to count the cycles of the tuning-fork record for a given number of revolutions. This process would have been very laborious had it been necessary to count each cycle individually; however, by means of a transparent celluloid interpolator, consisting of ten uniformly spaced radial lines, this work was facilitated materially. Since it is probable that the true speed—time curve of a large machine as it slows down is a continuous curve, the data taken from the chronogram were plotted, and a

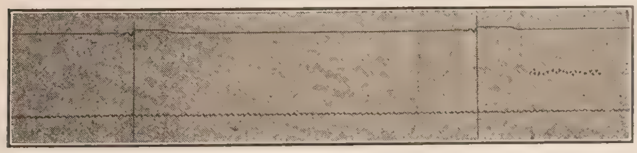

FIG. 4—TYPICAL RECORD FROM CHRONOGRAPH SHOWN IN FIG. 3

smooth curve as shown in Fig. 5 was determined from the plotted points with the idea that this curve would be more nearly a true representation of the speed—time curve of the machine than the actual, plotted points. The use of this curve also facilitated the determination of the slopes, as the method of numerical differentiation involves the use of values of speed taken at constant intervals of time.

## METHOD OF OBTAINING SLOPE OF THE SPEED—TIME CURVE

The slope of the speed—time curve for any retardation run should be determined with the greatest amount of accuracy possible from the data available, because the value of the losses varies directly as this slope.

In finding the slope of a curve, the equation of which is unknown, the usual method is to construct a tangent to the curve at the point where the slope is desired. This graphical differentiation is, at best, inaccurate for most empirical curves, and especially so when the curve approaches a straight line.

Instead of this somewhat crude and inexact method, the principles of numerical differentiation have been applied, and it is believed that in this way a considerably higher degree of precision has been obtained than would have been possible using the strictly graphical method. The principles of numerical differentiation are fully described in many standard mathematical works;[3, 4, 5, 6]—hence the derivation and proof of this process lie outside the scope of this paper. In order that its application to the determination of angular retardation may be clearly understood, however, a practical outline of the method is included.

In applying this method to an empirical curve of

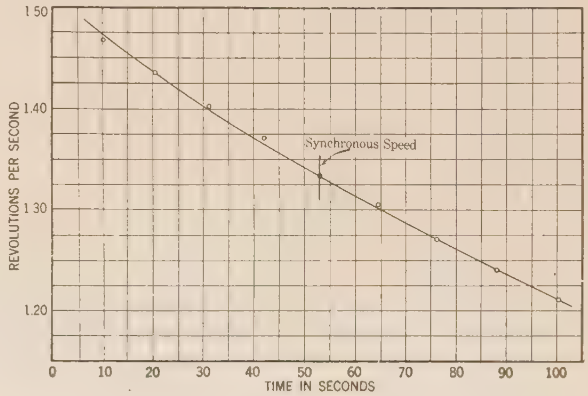


FIG. 5—TYPICAL SPEED—TIME CURVE

unknown equation $y = f(x)$, values of $x$ are taken (throughout the range of the curve under consideration) with a constant increment $h$, as shown in Fig. 6, so that

$$\begin{aligned} x_1 - x_0 &= h; \\ x_2 - x_1 &= h \\ &\cdots \\ &\cdots \\ x_n - x_{n-1} &= h \end{aligned}$$

Corresponding values $y$ are then taken from the curve; ($i.\ e.$, $y_0, y_1, y_2, \ldots y_{n-1}, y_n$).

Differences between successive values of $y$ are then computed, thus:

$$\begin{aligned} y_1 - y_0 &= a_0 \\ y_2 - y_1 &= a_1 \\ y_3 - y_2 &= a_2 \\ &\cdots \\ &\cdots \\ y_n - y_{n-1} &= a_{n-1} \end{aligned}$$

The values $a_0, a_1, a_2, \ldots a_n$, obtained in this manner, are known as differences of the first order. In the same

fashion, the differences of the second order are computed thus:

$$
\begin{aligned}
a_1 - a_0 &= b_0 \\
a_2 - a_1 &= b_1 \\
a_3 - a_2 &= b_2 \\
&\;\;\vdots \\
a_n - a_{n-1} &= b_{n-1}
\end{aligned}
$$

This process is continued until the desired number of differences has been taken. The Difference Table

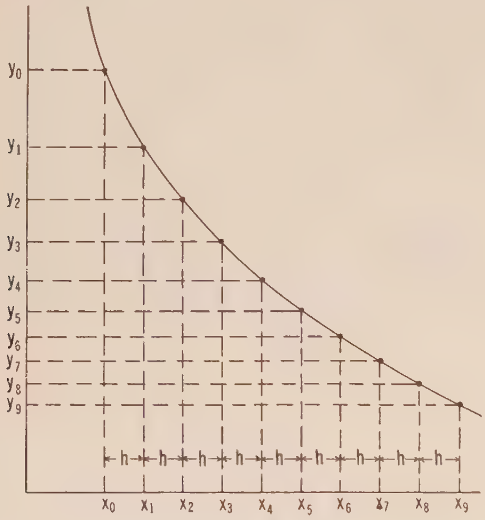


FIG. 6

(Table II) is then constructed with the values thus obtained.

The question of how many differences to include in the table requires some attention. In the somewhat special case where, in the range under consideration, the original curve can be exactly represented by a polynomial of $n$th degree, the $n$th order of difference will be constant and the $n + 1$st order will vanish. In such a case, the slope as calculated from the Difference Table will be rigorously correct.

TABLE II
DIFFERENCE TABLE

| $x$ | $y$ | $\Delta_1$ | $\Delta_2$ | $\Delta_3$ | $\Delta k$ |
|---|---|---|---|---|---|
| $x_0$ | $y_0$ | | | | |
| | | $a_0$ | | | |
| $x_1$ | $y_1$ | | $b_0$ | | |
| | | $a_1$ | . | $c_0$ | |
| $x_2$ | $y_2$ | | $b_1$ | | $m_0$ |
| | | $a_2$ | | $c_1$ | |
| $x_3$ | $y_3$ | | $b_2$ | . | $m_1$ |
| | | $a_3$ | | . | |
| $x_4$ | $y_4$ | | . | | . |
| | | . | | . | |
| . | . | | . | | $m_{n+1-k}$ |
| | | . | | $c_{n-2}$ | |
| $x_n$ | $y_n$ | | $b_{n-1}$ | | |
| | | $a_n$ | | . | |
| $x_{n+1}$ | $y_{n+1}$ | | | | |

Where:

$$
\begin{array}{lll}
x_1 - x_0 = h & y_1 - y_0 = a_0 & a_1 - a_0 = b_0 \\
x_2 - x_1 = h & y_2 - y_1 = a_1 & a_2 - a_1 = b_1 \\
\cdots & \cdots & \cdots \quad \text{etc.} \\
x_{n+1} - x_n = h & y_{n+1} - y_n = a_n & a_n - a_{n-1} = b_{n-1}
\end{array}
$$

More frequently, however, it is found that some order of difference is approximately constant, while successive orders tend to disperse irregularly. Such behavior as this is due to discrepancies between some of the tabulated values of $y$ and the corresponding values of a polynomial, which approximately, but not exactly coincides with the original function in the range under consideration. Such discrepancies may be the result of either errors in the empirical data, or of the fact that the original function cannot be represented exactly by a polynomial in the interval being studied. The magnitude of such deviations from the polynomial function may be determined for each of the tabulated values of $y$ by the use of a correction term (which is evaluated by trial) multiplied by the binomial coefficients.[6]

An inspection of Table III will make this clear.

TABLE III
SHOWING THE INFLUENCE OF AN ERROR $\epsilon$ IN ONE VALUE OF $y$ ON THE SUCCESSIVE DIFFERENCES

| $x$ | $y$ | $\Delta_1$ | $\Delta_2$ | $\Delta_3$ | $\Delta_4$ |
|---|---|---|---|---|---|
| $x_0$ | $y_0$ | | | | |
| | | $a_0$ | | | |
| $x_1$ | $y_1$ | | $b_0$ | | |
| | | $a_1$ | | $c_0$ | |
| $x_2$ | $y_2$ | | $b_1$ | | $d_0 + \epsilon$ |
| | | $a_2$ | | $c_1 + \epsilon$ | |
| $x_3$ | $y_3$ | | $b_2 + \epsilon$ | | $d_1 - 4\epsilon$ |
| | | $a_3 + \epsilon$ | | $c_2 - 3\epsilon$ | |
| $x_4$ | $y_4 + \epsilon$ | | $b_3 - 2\epsilon$ | | $d_2 + 6\epsilon$ |
| | | $a_4 - \epsilon$ | | $c_3 + 3\epsilon$ | |
| $x_5$ | $y_5$ | | $b_4 + \epsilon$ | | $d_3 - 4\epsilon$ |
| | | $a_5$ | | $c_4 - \epsilon$ | |
| $x_6$ | $y_6$ | | $b_5$ | | $d_4 + \epsilon$ |
| | | $a_6$ | | $c_5$ | |
| $x_7$ | $y_7$ | | $b_6$ | | $d_5$ |
| | | $a_7$ | | $c_6$ | |
| $x_8$ | $y_8$ | | $b_7$ | | |
| | | $a_8$ | | | |
| $x_9$ | $y_9$ | | | | |

This table shows the influence of an error $\epsilon$ in any tabulated value of $y$ on the successive differences. It will be seen that the original error is multiplied by the binomial coefficients in each order of difference.

The discrepancies between the original curve and polynomials of several different degrees may be determined as outlined above. These discrepancies will be found to be a minimum for a polynomial of, say, the $k$th degree. The Difference Table is therefore extended to include the $k$th order of differences, but is terminated at this point.

Having completed the Difference Table, the following formula for the derivative which was obtained from Newton's Interpolation formula may be used:

$$
\frac{d\,y}{d\,x} = \frac{1}{h}\left[ a_0 + (2n-1)\frac{b_0}{\underline{|2}} + (3n^2 - 6n + 2)\frac{c_0}{\underline{|3}} + (4n^3 - 18n^2 + 22n - 6)\frac{d_0}{\underline{|4}} \;\ldots\ldots \right] \quad (3)
$$

where $n$ may be defined as $\dfrac{x - x_0}{h}$, and where $a_0$, $b_0$, $c_0$, $d_0$, etc. are obtained from the Difference

Table, and $h$ is the constant interval between successive values of $x$.

This formula is rigorously true for all values of $n$, provided some order of differences, (say the $k$th), is constant. It is approximately true if the $k$th order of differences is approximately constant, particularly for fractional values of $n$. Since it is only the sequence of the subscripts in the Difference Table that is significant, any value of $x$ may be designated as $x_0$ provided the following value is called $x_1$, etc. Thus it is clear that $n$ may always be made fractional.

In the particular case where the derivative at a tabulated point is desired, $n$ vanishes and Equation (3) reduces to

$$\frac{dy}{dx} = \frac{1}{h}\left[a_0 - \frac{b_0}{2} + \frac{c_0}{3} - \frac{d_0}{4} + \ldots\right] \quad (4)$$

Using Equations (3) and (4), the slope of the original

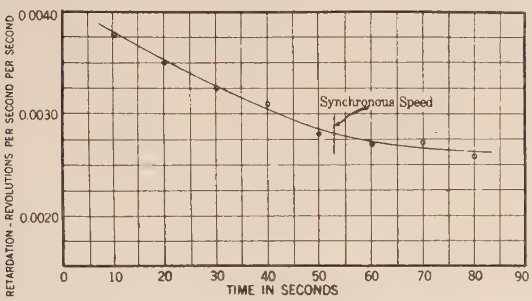


FIG. 7—TYPICAL RETARDATION CURVE

curve may be calculated at as many points as may be desired.

In determining generator losses, the slope of the speed—time curve might be calculated for the point corresponding to synchronous speed only, since this is the only value used in the calculations. However, the slopes were calculated for a number of points along the speed—time curve, and a curve of retardation against time was plotted. Fig. 7 is a typical retardation curve. From this curve the value of the slope at synchronous speed was read. In order that any deviation from its general trend might be detected and checked for errors, a curve of retardation against time was used instead of a single calculated point.

## CONCLUSIONS

It is believed that the chronograph is considerably more accurate than the tachometer and stop watch.

In addition to being more accurate than the stop watch, the chronograph is applicable to tests upon generators whose $W R^2$ is relatively low and which therefore slow down rapidly, whereas the stop watch method is not well adapted to use on such tests.

Due to the inherent accuracy of the chronograph, it is not necessary to take data throughout as great a range of speed during a retardation run as in the case of the stop watch method. Experience with generator tests on the Alabama Power Company system has shown that a range of from 10 per cent above synchronous speed to approximately 10 per cent below synchronous speed is adequate. The average time required for such a retardation run is approximately three minutes.

An additional advantage inherent in the use of the chronograph is the fact that it produces a permanent graphical record, thus reducing the chance for personal errors to creep in.

While the method of numerical differentiation is not new, it is felt that its advantages in connection with the determination of the retardation of generators have not been generally recognized. This principle constitutes a useful tool which may be readily employed.

It is realized that the method of determining slopes as outlined above is not mathematically rigorous unless some order of difference becomes constant. The type of curves encountered when considering the speed—time characteristics of a generator under the retarding forces of its losses in general does not give a constant set of differences. This is not surprising when it is remembered that the windage loss, which is always present, varies as a variable power of the speed.

It is felt, however, that the results obtained from this admittedly approximate method are of a considerably higher degree of precision than would have been obtainable from a strictly graphical method, and that they are well within the range of engineering accuracy. This, of course, is all that may be expected from data obtained from measurements made in the field where laboratory methods are inapplicable.

The use of this principle has produced consistent results wherever it has been applied by the authors. Typical results of two tests, each of which were duplicated, are tabulated below:

| Run No. | Retardation rev. per sec. per sec. | Per cent deviation from the average |
|---|---|---|
| 1 | −0.001763 | 0.45 |
| 2 | −0.001747 | 0.45 |
| Average | −0.001755 | |
| 1 | −0.001549 | 0.16 |
| 2 | −0.001554 | 0.16 |
| Average | −0.001552 | |

The close agreement between the duplicate runs seems to justify considerable confidence in the accuracy of this method of recording the speed of the generator and of obtaining the slope of the speed—time curve.

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Abridgment of

# 1928 Lightning Experience on 132-Kv. Lines of the American Gas & Electric Company

BY PHILIP SPORN*

Member, A. I. E. E.

***Synopsis.***—*This paper gives the operating experience of some thousand miles of 132-kv. transmission lines analyzed from the lightning point of view. The lightning experience during three years operation of the system is compared. In addition, the effect of ground wires, grading shields, and tower footing ground resistances is discussed from data secured under operating conditions. The comparative reliability of single- and two-circuit lines is analyzed from the data recorded. Cases of damage to insulator strings, hardware, etc., are tabulated and discussed from the point of the severity of the damage and the location on the phase wires. Yearly averages of lightning outages per 100 mi. of line per year are given for the different lines and from these figures comparisons made for the different types of line construction.*

*A three year record is given of the percentage of lightning outages on the 1000-mi. network.*

* * * * *

## Introduction

THIS paper is a continuation of a series of papers[1,2,3,4,5] that has been presented before the Institute during the past four years, on the performance of a number of 132-kv. steel tower transmission lines on the systems of the subsidiaries of the American Gas & Electric Company during the years 1925, 1926, and 1927.

In this paper it is proposed to give the 1928 history of the system investigated and described in the previous papers.

## 1928 Performance

In Table I is given a brief résumé of the principal characteristics of the various circuits, together with the 1926, 1927, and 1928 lightning performance.

## Discussion of 1928 Experiences

1. *Effect of Ground Wire.* The beneficial effect of the ground wire has been further demonstrated from this year's record.

2. *One Ground Wire Against Two.* The only line operating with two ground wires—viz. the Windsor-Canton 55-mi. line—showed an outage of 3.6 per 100 mi. of line per year. As compared with all other lines on the system operating with one ground wire, the outages on the 100-mi. basis are about one-third as many.

3. *Relative Shielding of the Three Phases by Ground Wires.* The location of damage found on inspection as regards top, middle, and bottom conductors has been summarized in Table III.

On the Turner-Logan Line, not equipped with ground wire, there were 28 cases of damage on the top conductor, 12 on the middle, and 9 on the bottom, showing a tendency for flashover to concentrate on the top conductor.

From the analysis of this Table, it again seems that there considerable grounds for believing induced lightning strokes are the cause of a great many cases of line flashover; it is difficult to explain otherwise approximately equal damage on bottom and top phases, particularly where the line is equipped with a ground wire at the peak of the tower above all three phases.

4. *Grading Shield Experiences.* The use of grading shields is discussed from two points of view; first, that of line outage, and, second, that of damage to the line,—(insulators, conductors, and hardware). The results of this year's operation as analyzed from the point of view of grading shields, therefore, indicates a slightly smaller number of outages with lines equipped with shields than without, although it is believed that the data are not sufficiently comprehensive to prove this point definitely.

5. *Ground Resistance.* In an attempt to determine the effect of tower footing resistances on the line flashover, so far as the operating records can throw any light on this subject, two lines have been analyzed.

It does not seem possible to gather any conclusive evidence from the data presented on these towers, or from data on other lines where flashovers occurred and tower footing resistances were known which would indicate any tendency for the flashover to be concentrated on the sections of the line with high tower footing resistance.

6. *Single-Circuit against Double-Circuit Outages.* To compare the outages on single-circuit and double-circuit lines, data have been recorded in Table VI. These data confirm not only that obtained last year, but also records of two-circuit line operation obtained on other systems in the country, where it is reported about 20 per cent of the lightning troubles tripped both lines of the two-circuit system.

7. *Lightning Outages on 132-Kv. Lines.* In order to throw some light on this, an analysis of line outages has been made to show the relative importance of lightning outages on the line. For all 132-kv. lines on the system for the years 1926, 1927, and 1928, these data are recorded in Table VII.

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1. For references see Bibliography.

*Complete copy upon request.*

A summation of the 1928 lightning experience shows the following:

1. The effectiveness of the ground wire was further demonstrated and is brought home strikingly by the following:

The line outages on the Turner-Logan line, a steel tower circuit line without ground wires, per 100 mi. of line were 32.3; on the Logan-Sprigg line, a wood pole line without ground wire 42.9; on all the other lines having ground wires 11.7.

2. The effectiveness of two ground wires and the short-span line built closely to the ground is again demonstrated in the case of the Windsor-Canton Line. This line showed the same consistent performance as in the past, with 3.7 outages per 100 mi. of line.

3. The effect of the ground wire in equalizing the lightning voltages on the lines is again demonstrated this year the same as by the data presented for the 1927 line operation. This year the cases of insulator and wire damage found where ground wires are employed were 59 on the top conductor, 37 on the middle conductor, and 54 on the bottom conductor. Last year's figures showed, correspondingly, 24, 25, and 29 cases of damage. On the steel tower line not equipped with ground wire, in 1928 there were found 28 cases of damage on the top wire, 12 on the middle, and 9 on the

TABLE I

| Column No.—1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|
| Line designation | Glenlyn Roanoke | Glenlyn Switchbk. | Lima Fostoria | Lima Twin Br. | Logan Sprigg | Philo Canton | Philo Crooksville | Philo Turner | Roanoke Danville |
| Length of line (miles) | 65.0 | 30.0 | 45.6 | 128.5 | 21.0 | 73.0 | 15.4 | 118.7(L) | 65.0 |
| Line placed in service (date) No. 1 | 6/13/26 | 8/13/27 | 9/3/25 | 9/18/25 | 6/28/26 | 9/28/24 | 9/28/24 | | 9/16/26 |
| No. 2 | 6/13/26 | 8/13/27 | . . (F) | . . | . . | 9/28/24 | . . | 4/22/26 | . . |
| Number of circuits 1928 | 2 | 2 | 1 | 1 | 1 | 2 | 1 | 1 | 1 |
| Number of ground wires 1928 | 1 | 1 | 1 | 1 | None | 1 | 1 | 1 | 1 |
| Ground wire installed (date) | 6/13/26 | 8/13/27 | 3/. . /26 | 3/. . /26 | . . | 4/. . /26 | 3/. . /26 | 4/22/26 | 9/16/26 |
| Grading shields Line No. 1 | R & R | R & H | None | R & H | None | R & H | None | . . . | R & R |
| Grading shields Line No. 2 | R & R | R & H | . . | . . | . . | R & H | . . | None | . . |
| Grading shields (date) installed on Line No. 1 | 5/16/28 | 8/13/27 | . . | 6/ 7/26 | . . . | 5/13/26 | . . | . . | 10/12/28 |
| Grading shields (date) installed on Line No. 2 | 4/30/28 | 8/13/27 | . . | . . | . . | 1925-26 5/13/26 | . | . | . . |
| 1926 Lightning Performance | | | | | | | | | |
| Number of circuits | 2 | 2 | 1 | 1 | 1 | 2 2 | 1 | 1 | 1 |
| One circuit only tripped out | 16 | . . | 9 | 23 | 3 | 13 | 3 | 11 | 0 |
| Both circuits tripped out | 4 | . . | . . | . . | . . | 2 | . . | . . | . . |
| Total outages | 20 | . . | 9 | 23 | 3 | 88 15 | 3 | 11 | 0 |
| Circuit outages per 100 mi. of line per year | 48(A) | 0(B) | 19.8 | 17.9 | 31(A) | 120 20.5 | 19.5 | 10.6 | 0(A) |
| Circuit outages per 100 mi. of circuit per year | 24(A) | 0(B) | 19.8 | 17.9 | 31(A) | 60 10.3 | 19.5 | 156 | 0(A) |
| 1927 Lightning Performance | | | | | | | | | |
| Number of circuits | 2 | 2 | 1 | 1 | 1 | 2 | 1 | 1 | 1 |
| One circuit only tripped out | 21(C) | . . | 4 | 8 | 7 | 3(C) | 1 | 7 | 16 |
| Both circuits tripped out | 3 | . . | . . | . . | . . | 1 | . . | . . | . . |
| Total outages | 24 | 0 | 4 | 8 | 7 | 4 | 1 | 7 | 16 |
| Circuit outages per 100 mi. of line per year | 37 | 0(A) | 8.8 | 6.2 | 33.3 | 5.5 | 6.5 | 5.9 | 24.6 |
| Circuit outages per 100 mi. of circuit per year | 18.5 | 0(A) | 8.8 | 6.2 | 33.3 | 2.8 | 6.5 | 5.9 | 24.6 |
| Damage to insulators (no. towers affected) | 17 | 1 | 7(D) | 28(D) | 0(E) | 0 | 0 | 2 | 14 |
| Damage to conds. and hardware (no. towers affected) | 14 | 3 | 5 | 0 | 0(E) | 3 | 0 | 1 | 5 |
| Total cases of damages | 20 | 3 | 9 | 28(D) | 0(E) | 3 | 0 | 2 | 14 |
| Cases of damage per line outage | 0.83 | 00 | 2.25 | 1.16 | 0 | 0.75 | 0 | 0.29 | 0.87 |
| 1928 Lightning Performance | | | | | | | | | |
| Number of circuits | 2 | 2 | 1 | 1 | 1 | 2 | 1 | 1 | 1 |
| One circuit only tripped out | 5 | 1 | 1 | 11 | 9 | 10 | 2 | 12 | 13 |
| Both circuits tripped out | 2 | 1 | . . | . . | . . | 2 | . . | . . | . . |
| Total outages | 7 | 2 | 1 | 11 | 9 | 12 | 2 | 12 | 13 |
| Circuit outages per 100 mi. of line per year | 10.8 | 6.7 | 2.2 | 8.6 | 42.9 | 16.4 | 13. | 7.1(I) | 20. |
| Circuit outages per 100 mi. of circuits per year | 5.4 | 3.4 | 2.2 | 8.6 | 42.9 | 8.2 | 13. | 7.1(I) | 20. |
| Damage to insulators (no. towers affected) | 2 | 1 | 2 | 4 | 5 | 10 | 2 | 10 | 18 |
| Damage to conductors | 2 | 2 | 1 | 0 | 0 | 6 | 1 | 6 | 5 |
| Arcing rings burned (no. towers affected) | 5 | 3 | . . | 4 | . . | 10 | . . | 0 | . . |
| Total cases of damages | 6 | 4 | 2 | 4 | 5 | 11 | 2 | 11 | 18 |
| Cases of damages per line outage | 0.86 | 2.0 | 2.0 | 0.36 | 0.55 | 0.92 | 1.0 | 0.92 | 1.38 |

(A Corrected for one calendar year (In service only part of year)
(B) Not in service
(C) One circuit out of service at time of flashover in one case
(D) Probably partly accumulation of two previous years
(E) Superficial inspection—towers not climbed
(F) Operated at 66 kv. 8/3/24 to 9/3/25
(G) R. & R. is ring and ring—R. & H. is ring and horn
(H) On No. 1 circuit—none on No. 2 circuit
(I) Rutland-So. Point No. 2 (50.3 mi.) also on this circuit
(J) Both circuits operated as part of lines to Philo, Turner & Crooksville
(K) Chargeable to three years operation
(L) In 1928, 169 miles

bottom. This evidence seems to show beyond a doubt that a great many cases of induced lightning surges on lines are the cause of line flashover.

4. The operating record of grading shields on insulator strings shows, as has been pointed out in the past based on theory, that their use results in very little reduction in line outages. This year's experience, however, adds confirming data to show that they are of great importance in reducing damage to line conductor and insulators, where the grading shield design has been properly and carefully worked out. This benefit is shown both in the decrease in severed conductor strands and in the great reduction in cascading of the insulator strings, where grading shields were used.

5. No evidence appears from this year's operating records which indicates that flashovers tend to concentrate on towers with high footing resistances. Tables IV and V show this quite conclusively. The tower footing resistances where flashovers were encountered on two different lines, one with ground wire and one without ground wire, both having grading shield assemblies, varied from 1.5 to over 250 ohms.

6. On two-circuit lines only 19 per cent of the outages have tripped out both lines. In the other 81 per cent of the cases only one line tripped. It is therefore apparent that, from a point of continuity of service, the two-circuit line is much more reliable than a single-circuit line from the lightning aspect. Last year 16

TABLE I (Continued)

| Column No. 1<br>Line Designation | 11<br>Roanoke<br>Reusens | 12<br>Rutland<br>So. Point | 13<br>Saltville<br>Kingsport | 14<br>So. Bend<br>Mich. City | 15<br>Switchbk.<br>Logan | 16<br>Switchbk.<br>Saltville | 17<br>Turner<br>Logan | 18<br>Twin Br.<br>So. Bend | 19<br>Windsor<br>Canton | 20<br>Crooksville<br>So. Point |
|---|---|---|---|---|---|---|---|---|---|---|
| Length of line (miles) | 43.0 | 50.3(J) | 56.0 | 40.0 | 50.0 | 46.0 | 40.2 | 4.9 | 55.0 | 102.3 |
| Line placed in service (date)......No. 1 | 5/ 5/26 | 2/26/28 | 8/25/27 | 6/24/26 | 11/27/27 | 1/016/27 | 1/30/26 | 4/5/25 | 9/../17 | 2/26/28 |
| No. 2 | 9/ 9/27 | 3/15/26 | .. | .. | 11/27/27 | .. | .. | 4/5/25 | 9/../17 | .. |
| Number of circuits.......... 1928 | 2 | 1 | 1 | 1 | 2 | 1 | 2 | 2 | 2 | 1 |
| Number of ground wires.......... 1928 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 |
| Ground wire installed | 5/ 5/26 | 3/15/26 | 8/25/27 | 3/../26 | 11/27/27 | 10/16/27 | 9/../28 | 3/../26 | 9/../17 | 4/22/26 |
| Grading shields..........Line No. 1 | R & H | R & R | R & H | None | R & H | R & H | R & H | R & H | None | R & R(G) |
| Grading shields..........Line No. 2 | R & H | None | .. | .. | R & H | .. | R & H | R & H | None | .. |
| Grading shields (date) installed on .....<br>Line No. 1 | 5/22/26 | 2/26/28 | 8/25/27 | .. | 11/27/27 | 10/16/27 | 7/20/26 | 6/8/26 | .. | 2/26/28 |
| Grading shields (date installed on.....<br>Line No. 2 | 9/ 9/27 | .. | .. | .. | 11/27/27 | .. | 7/20/26 | 6/8/26 | . | .. |
| 1926 Lightning Performance | | | | | | | | | | |
| Number of circuits | 1 | 1 | 1 | 1 | 2 | 1 | 2 | 2 | 2 | .. |
| One circuit only tripped out | 13 | 3 | .. | .. | .. | .. | 16 | 0 | 9 | |
| Both circuits tripped out | .. | .. | .. | .. | .. | .. | 2 | 0 | 2 | |
| Total outages | 13 | 3 | .. | .. | .. | .. | 18 | 0 | 11 | |
| Circuit outages per 100 mi. of line per year | 36.6(A) | 6.3(A) | 0(B) | .. | 0(B) | 0(B) | 44.8 | 0 | 20 | |
| Circuit outages per 100 mi. of circuit per year | 36.6(A) | 6.3(A) | 0(B) | .. | 0(B) | 0(B) | 22.4 | 0 | 10 | |
| 1927 Lightning Performance | | | | | | | | | | |
| Number of circuits | 1 | 1 | 1 | 1 | 2 | 1 | 2 | 2 | 2 | .. |
| One circuit only tripped out | 16 | 7 | .. | 4 | .. | .. | 20 | 1 | 2(C) | |
| Both circuits tripped out | .. | .. | .. | .. | .. | .. | 4 | 1 | 0 | |
| Total outages | 16 | 7 | .. | 4 | .. | .. | 24 | 2 | 2 | |
| Circuit outages per 100 mi. of line per year | 37.2 | 13.9 | 0(A) | 10 | 0(A) | 0(A) | 57.2 | 41. | 3.6 | |
| Circuit outages per 100 mi. of circuit per year | 37.2 | 13.9 | 0(A) | 10 | 0(A) | 0(A) | 28.6 | 20.5 | 1.8 | |
| Damage to insulators (No. towers affected) | 2 | 0 | 0 | 1 | 0 | 0 | 2 | 1 | 0 | |
| Damage to conds. and hardware (No. towers affected) | 7 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | |
| Total cases of damages | 7 | 0 | 0 | 1 | 0 | 0 | 5 | 1 | 0 | |
| Cases of damage per line outage | 0.44 | 0 | .. | 0.25 | .. | .. | 0.21 | 0.50 | 0 | |
| 1928 Lightning Performance | | | | | | | | | | |
| Number of circuits | 2 | 2 | 1 | 1 | 2 | 1 | 2 | 2 | 2 | 1 |
| One circuit only tripped out | 6 | (J) | 5 | 7 | 16 | 5 | 12 | 0 | 2 | 4 |
| Both circuits tripped out | 4 | | .. | .. | 2 | .. | 1 | 0 | 0 | .. |
| Total outages | 10 | | 5 | 7 | 18 | 5 | 13 | 0 | 2 | 4 |
| Circuit outages per 100 mi. of line per year | 23.3 | | 8.9 | 17.5 | 36. | 10.9 | 32.3 | 0 | 3.6 | 3.9 |
| Circuit outages per 100 mi. of circuit per year | 11.7 | | 8.9 | 17.5 | 18. | 10.9 | 16.2 | 0 | 1.8 | 3.9 |
| Damage to insulators (No. towers affected) | 7 | | 1 | 4 | 5 | 1 | 23(K) | 0 | 0 | 0 |
| Damage to conductors | 1 | | 1 | 1 | 2 | .. | 22(K) | 0 | 1 | 0 |
| Arcing rings burned (No. towers affected) | 25 | | 6 | .. | 12 | 3 | 25(K) | 0 | .. | 3 |
| Total cases of damages | 28 | | 6 | 4 | 14 | 3 | 38(K) | 0 | 1 | 3 |
| Cases of damage per line outage | 2.8 | .. | 1.2 | 0.57 | 0.78 | 0.6 | 1.07 | .. | 0.50 | 0.75 |

(A) Corrected for one calendar year (In service only part of year)
(B) Not in service
(C) One circuit out of service at time of flashover in one case
(D) Probably partly accumulation of two previous years
(E) Superficial inspection—towers not climbed
(F) Operated at 66 kv. 8/3/24 to 9/3/25
(G) R. & R. is ring and ring—R. & H. is ring and horn
(H) On No. 1 circuit—none on No. 2 circuit
(I) Rutland-So. Point No. 2 (50.3 mi.) also on this circuit
(J) Both circuits operated as part of lines to Philo, Turner & Crooksville
(K) Chargeable to three years operation
(L) In 1928, 169 miles

per cent of the outages on two-circuit lines tripped both circuits.

TABLE III
1928
LOCATION OF TROUBLE ON INSULATORS AND WIRES

| Line | Total | Top | Middle | Bottom |
|---|---|---|---|---|
| Glen Lyn-Roanoke | 11 | 5 | 3 | 3 |
| Glen Lyn-Switchback | 6 | 1 | 0 | 5 |
| Lima-Fostoria | 2 | 2 | 0 | 0 |
| Lima-Twin Branch | 4 | 2 | 0 | 2 |
| *Logan-Sprigg | 5 | 3† | 2‡ | — |
| Philo-Canton | 14 | 7 | 4 | 3 |
| Philo-Crooksville | 2 | 1 | 0 | 1 |
| Philo-Turner | 14 | 8 | 3 | 3 |
| Roanoke-Danville | 26 | 7 | 8 | 11 |
| Roanoke-Reusens | 36 | 10 | 8 | 18 |
| Saltville-Kingsport | 7 | 4 | 2 | 1 |
| So. Bend-Michigan City | 4 | 2 | 0 | 2 |
| Switchback-Logan | 21 | 8 | 7 | 3 |
| Switchback-Logan | | 1† | — | 2† |
| Switchback-Saltville | 5 | 2 | 1 | 2 |
| §Turner-Logan | 55 | 28 | 12 | 9 |
| Turner-Logan | | 3† | — | 3† |
| Windsor-Canton | 1 | 0 | 1 | 0 |
| Totals | 213 | 94 | 51 | 68 |
| Total excluding (†) and (‡) and Turner-Logan | 150 | 59 | 37 | 54 |

*Logan-Sprigg Line, wood pole, no ground wire.
†Horizontal configuration = outside wires.
‡Horizontal configuration = middle wires.
§Turner-Logan Line, no ground wire.

TABLE IV
TOWER GROUND RESISTANCE OF TOWERS WHERE FLASHOVERS OCCURRED
ROANOKE-REUSENS LINE

| | |
|---|---|
| Total number of towers in the line | 200 |
| Total number of towers with flashovers | 28 |
| Average resistance per tower for whole line | 32.6 |
| Average resistance per tower of those with F. O. | 45.4 |
| Ratio of resistance $\dfrac{\text{flashed over towers}}{\text{average of line}}$ | 1.40 |

TABLE V
TOWER GROUND RESISTANCE OF TOWERS WHERE FLASHOVERS OCCURRED
TURNER-LOGAN LINE

| | |
|---|---|
| Total number of towers in the line | 153 |
| Total number of towers with flashovers | 38 |
| Average resistance per tower for whole line | 22.0 |
| Average resistance per tower for those with flashover | 29.9 |
| Ratio of resistance $\dfrac{\text{flashed over towers}}{\text{average of line}}$ | 1.36 |

TABLE VI
1928 LIGHTNING OUTAGES ON TWO-CIRCUIT LINES

| Line | Total | One circuit out | Both circuits out | Per cent |
|---|---|---|---|---|
| Glen Lyn-Roanoke | 7 | 5 | 2 | |
| Glen Lyn-Switchback | 2 | 1 | 1 | |
| Philo-Canton | 12 | 10 | 2 | |
| Roanoke-Reusens | 10 | 6 | 4 | |
| Switchback-Logan | 18 | 16 | 2 | |
| Turner-Logan | 13 | 12 | 1 | |
| Windsor-Canton | 2 | 2 | 0 | |
| Total | 64 | 52 | 12 | |
| Single-circuit outages—per cent | | | | 81 |
| Double-circuit outages—per cent | | | | 19 |

7. Analysis of the damage found on the line shows that the average of the cases of damage per line outage for the entire system is 1.03. The maximum number of cases of damage per lightning outage is 2.8 and in two other cases the damage ran as high as two per line trip-out. The corresponding figure of line damage per outage during 1927 was slightly less than one being 0.72. Since the theoretical figure for damage per line outage would be expected to be in the order of two, it is believed that the average figure of one per line tripout observed this year on these lines may be due in part to the effective protection offered by the grading shields.

TABLE VII
132-KV. LINE OUTAGES

| Line | 1926 | | | 1927 | | | 1928 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total | Ltng. | Per cent Ltng. | Total | Ltng. | Per cent Ltng. | Total | Ltng. | Per cent Ltng. |
| Glen Lyn-Roanoke | 20 | 20 | 100.0 | 30 | 24 | 80.0 | 14 | 7 | 50.0 |
| Glen Lyn-Switchback | .. | .. | .. | .. | .. | .. | 2 | 2 | 100.0 |
| Lima-Fostoria | 17 | 9 | 53.0 | 4 | 4 | 100.0 | 1 | 1 | 100.0 |
| Lima-Twin Branch | 31 | 23 | 74.0 | 10 | 8 | 80.0 | 20 | 11 | 55.0 |
| Logan-Sprigg | 4 | 3 | 75.0 | 10 | 7 | 70.0 | 13 | 9 | 69.2 |
| Philo-Canton | 15 | 15 | 100.0 | 9 | 4 | 44.5 | 13 | 12 | 92.5 |
| Philo-Crooksville | 5 | 3 | 60.0 | 5 | 1 | 20.0 | 3 | 2 | 66.7 |
| Philo-Turner | 17 | 11 | 64.7 | 9 | 7 | 77.7 | 13 | 12 | 92.3 |
| Roanoke-Danville | .. | .. | .. | 17 | 16 | 94.0 | 21 | 13 | 61.8 |
| Roanoke-Reusens | 17 | 13 | 76.5 | 18 | 16 | 88.9 | 11 | 10 | 91.0 |
| Rutland-So. Point | 3 | 3 | 100.0 | 7 | 7 | 100.0 | .. | .. | .. |
| Saltville-Kingsport | .. | .. | .. | 2 | 0 | 0.0 | 8 | 5 | 62.5 |
| So. Bend-Michigan City | .. | .. | .. | 6 | 4 | 66.6 | 12 | 7 | 58.2 |
| Switchback-Logan | .. | .. | .. | .. | .. | .. | 22 | 18 | 81.8 |
| Switchback-Saltville | .. | .. | .. | 5 | 0 | 0 | 6 | 5 | 83.4 |
| Turner-Logan | 18 | 18 | 100.0 | 27 | 24 | 89.0 | 19 | 13 | 68.5 |
| Twin Branch-So. Bend | .. | .. | .. | 2 | 2 | 100.0 | 3 | 0 | 0.0 |
| Windsor-Canton | 11 | 11 | 100.0 | 2 | 2 | 100.00 | 5 | 2 | 40.0 |
| Crooksville-So. Point | .. | .. | .. | .. | .. | .. | 9 | 4 | 44.5 |
| Totals and averages | 158 | 129 | 81.6 | 163 | 126 | 77.2 | 195 | 133 | 68.2 |

Three year average per cent lightning outages = 75.1 per cent.

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Abridgment of

# Voltage Irregularities in D-C. Generators


BY J. T. FETSCH*

Associate. A. I. E. E.



***Synopsis.***—*This paper enumerates the voltage irregularities which may occur in d-c. generators. It gives a description of these irregularities, the cause of their occurrence, the magnitude of their values, and their effects on radio circuits; it also states the problem encountered in their measurement.*

*A method is described for the measurement of these voltage irregularities by the use of an oscillograph, a blocking condenser, and a current transformer.*

*A number of oscillograph records illustrative of the voltage irregularities existent in various d-c. generators is shown, and an analysis of the wave form made for each component of slow and fast ripple. These records were taken under various electrical and mechanical conditions of the generators. Comparisons between these records are made.*

*There are conclusions drawn as to features desirable in d-c. generators.*


## General Introduction

THE general idea is held that the voltage from a d-c. generator consists of a continuous, smooth, produced electromotive force, with practically no fluctuations. This opinion is decidedly a misapprehension, since in some cases the voltage irregularity may be as large as from 5 to 10 per cent, although in the majority of cases, the range is around from 1 to 2 per cent. The value of this irregularity encountered depends almost wholly on design, and is governed principally by the type of winding, shape and size of poles, the type and number of slots, to some degree upon the size of the machine, the air-gap, the electric and magnetic loading, the occasional lack of the interpole feature, and the method of fabrication.

## 2. Description of Method for Measuring Voltage Irregularities

This method gives a photographic record of the voltage irregularity under investigation by the combined use of an oscillograph, a current transformer, and a condenser. In Fig. 1 the oscillograph element $O_2$ is that used in the standard type of oscillograph and has a sensitivity of 1-cm. deflection on the screen per 50 milliamperes. In conjunction with this oscillograph element $O_2$, a current transformer $T_1$ is used so that the minute value of primary current composing the ripple may be stepped up to a useful value to operate the element $O_2$. A condenser $C_1$ of from 2 to 3 $\mu$fs. is inserted in series with the primary of the transformer to prevent direct current from flowing, yet allowing the ripple current to pass through. The switch $S_1$ is for protecting the element $O_2$ and the transformer $T_1$, and is always kept closed except during observations and photographic recording of the ripple wave form, and while the element is being calibrated. The variable resistance $R_1$ is about two ohms and is used to regulate

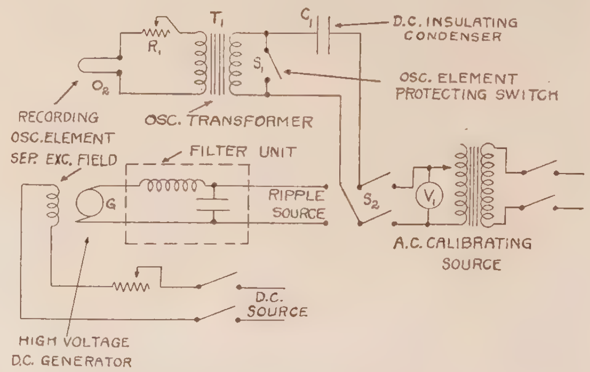



FIG. 1—DIAGRAM OF CONNECTIONS FOR MEASUREMENT OF VOLTAGE IRREGULARITIES

the amplitude of vibration of element $O_2$. The switch $S_2$ is used as a transfer from the unknown ripple source to the a-c. calibrating source. $G$ is a generator with separately excited field, whose ripple voltage is under investigation.

## 3. Voltage Irregularities which Occur with Explanation of the Origin of Each

An analysis of this problem by means of oscillographic

*Asst. Radio Engr., Naval Research Laboratory, Anacostia, D. C. Submitted with the approval of the Navy Department.

*Presented at the North Eastern District Meeting of the A. I. E. E., Springfield, Mass., May 7-10, 1930. Complete copy upon request.*

records proves that the following voltage irregularities exist collectively or in part in high-voltage d-c. generators:

a. Slot ripple.

b. Commutator ripple.

c. Armature reluctance variation ripple due to grain direction in steel.

d. Armature reluctance variation ripple due to improper physical alinement.

e. Speed variation due to improper shaft alinement of motor and generator.

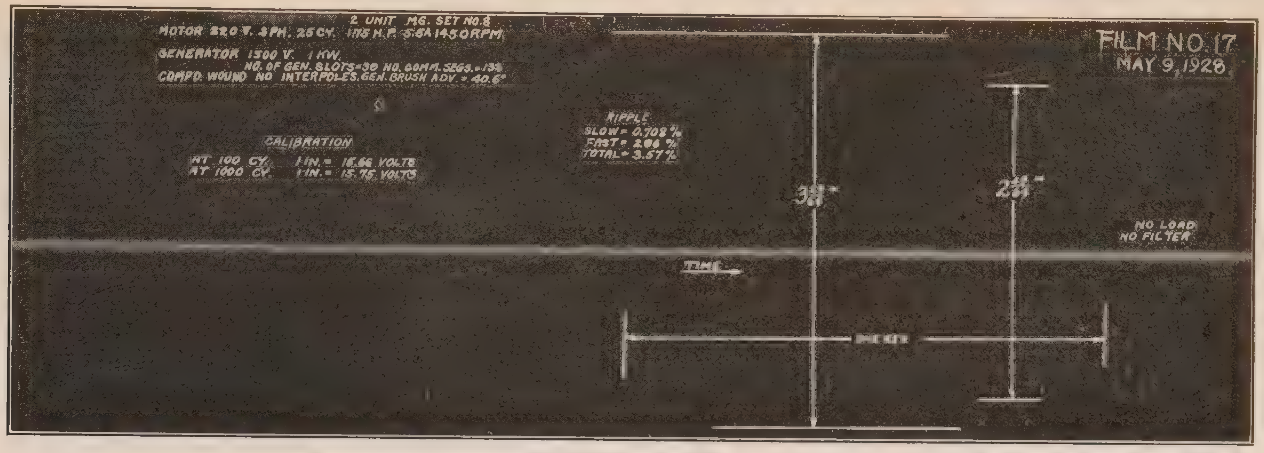
*A. Slot Ripple.* Slot ripple is due to resultant pulsations in magnetic flux which surge through the armature windings of the generator, thereby causing periodic voltages to appear at its terminals. These pulsations arise by virtue of the fact that the slots on the armature periphery are moving by the leading and trailing pole tips, thus effecting changes in magnetic reluctance and field distribution in the air-gap as they do so.

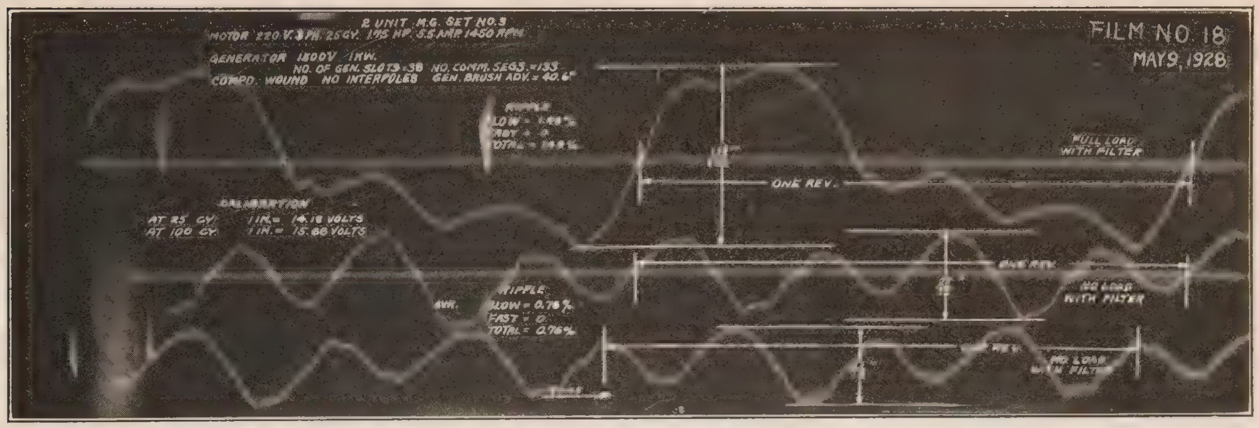
*B. Commutator Ripple.* Commutation ripple is that voltage irregularity arising from the reversal of current flow in the armature coils due to the brush passing from bar to bar of the commutator. When this current is changed in an armature coil, a reactance voltage is set up, which appears at the terminals of the generator.

*C. Armature Reluctance Variation Due to Grain Direction.* Another voltage variation noted in d-c. high-voltage generators is that due to grain direction in the sheet steel used for the armature material. This grain direction is a property imparted to the sheet steel during manufacture and causes the steel to have somewhat better magnetic properties in the direction of sheet rolling than in other directions. This permits pulsations in the magnetic circuit as the armature rotates, and therefore ultimately affects the terminal voltage of the generator.

*D. Armature Reluctance Variation Due to Improper Physical Alinement.* If an armature is not running true, so that the armature periphery and the field bore are both eccentric to the shaft, then the conditions represented may be such as to produce a reluctance variation, and so, a voltage irregularity. Also, if the armature shifts to and fro longitudinally, so that the pole face does not always cover the ends of the armature, the effective flux acting through the armature windings may be reduced at certain instants, causing voltage irregularities.

*E. Speed Variation Due to Improper Shaft Alinement of Motor and Generator.* As the steadiness of the generated d-c. voltage depends on the constancy of the generator speed, any factor causing variation in speed



will influence the terminal generated e. m. f. A few possibilities can be mentioned; as first, a variation in motor speed; second, a variation in torque on the generator armature; and third, misalinement of the motor and generator shafts. It is this latter factor that may play an important part in causing a voltage irregularity, sometimes being the greatest in magnitude, compared to any other.

## 5. Oscillographic Records of Voltage Irregularities in High-Voltage D-C. Generators

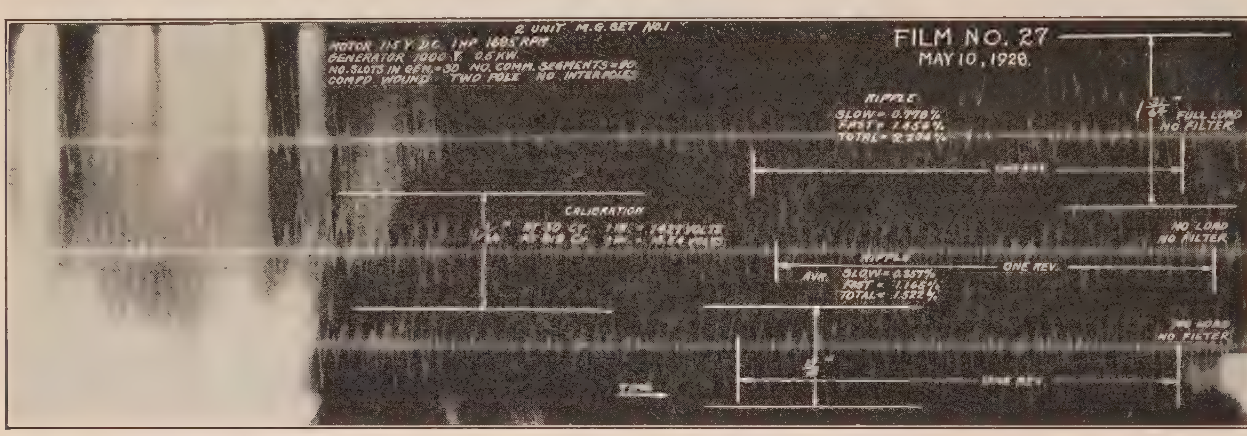
Herewith are presented examples of oscillograph records of voltage irregularities taken by the method described in this article. The records were taken from generator sources used as d-c. high-voltage supplies for radio equipment. These films show quite a few unexpected phenomena, and each film will be described separately, as almost every record brings out and substantiates some particular fact.

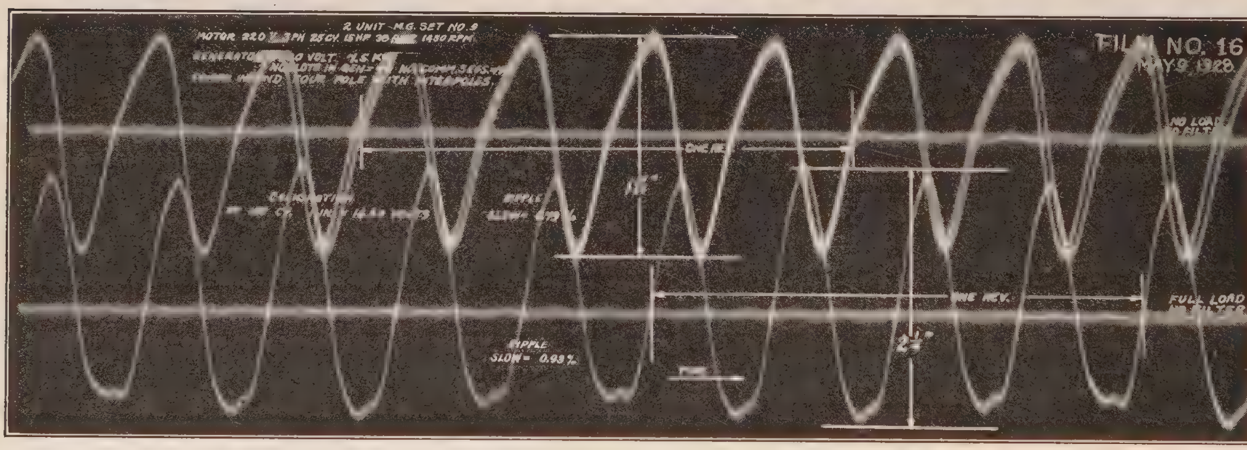
*Film No. 27.* The first oscillographic record to be presented is that of the generator of set No. 1, taken on Film No. 27. This two-pole generator has 30 slots and 90 commutator segments. It is devoid of the interpole feature, and does not have the proper pole coverage with respect to the slots for eliminating slot ripple. It is shunt-wound and has a single high-voltage commutator.

With a study of Film No. 27, it can be seen that slot ripple exists as is shown by the 30 pulsations occurring per revolution of the armature. This is a high-frequency ripple of 819 cycles per second, and is not extremely difficult to filter.

Some commutator ripple is also present due in part to the lack of the interpoles, and to the division of the winding. This too, like slot ripple, is of high frequency, but is not generally of very great amplitude as compared with other kinds of ripple.

The effect of grain direction in the armature can be observed and is seen to consist of four pulsations. This is a slow-speed voltage irregularity and requires a very large filter to eliminate effectively.



No other irregularities are discernible in this machine, and hence, indicate either the entire absence or the extreme smallness of their values.

A point to be noted is the variation in the amplitude of the ripple with load. In this particular generator, the ripple increased about 30 per cent from no-load to full load.

*Film No. 16.* The four-pole generator used in obtaining this film record is that of motor-generator set No. 9. It has 49 slots and 195 commutator segments. There are two high-voltage commutators connected in series; the machine has interpoles to take care of commutation, and has a compound field.

In this machine slot-ripple is non-existent as the design of the pole coverage with respect to the armature slots is such as to eliminate it.

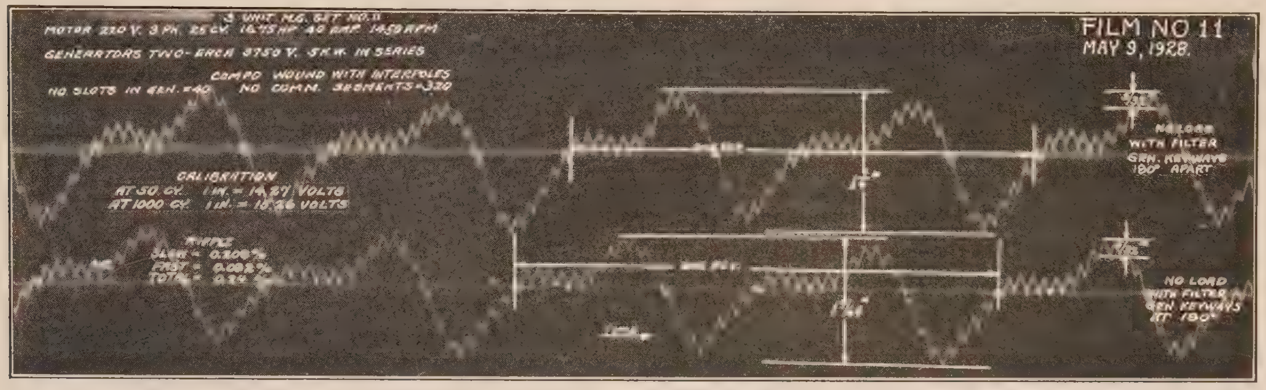
Commutator ripple is also non-existent; principally on account of the interpole feature.

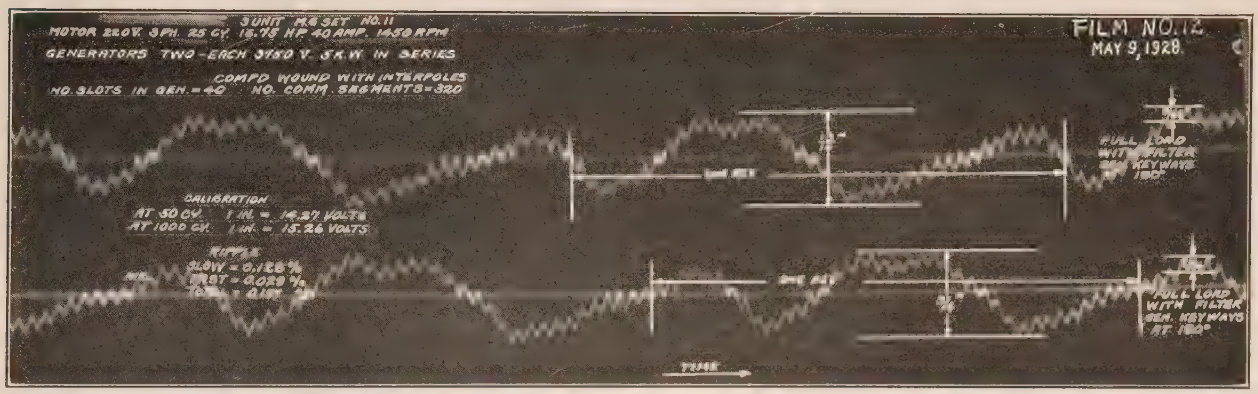
An armature reluctance variation e. m. f., due to grain direction, is seen to consist of four pulsations per revolution, which is in agreement with the number of poles. The amplitude of this ripple increases about 10 per cent from no-load to full load, and a small amount of saturation effect can be noticed on the full-load trace.

There is a slight indication that the speed of the machine varies with the revolution of the armature, as the peaks of the ripple-wave form recorded on the trace percentage of ripple and its wave form change with load. The reason for the change in wave form with load is due to the collective influence of the interpoles, armature reaction, and grain direction, and the added possibility of speed variation due to some factor, such as variable motor torque or the effect of the coupling.

*Films No. 17 and No. 18.* These two film records were taken from the two-pole generator of set No. 3. This machine has a compound field; its armature has 38 slots and 133 commutator segments. It is devoid of interpoles, and so, to insure reasonably good commutation, the brushes are advanced about 40 deg. in the direction of rotation.

Film No. 17 was recorded without a filter in the high-




are not all of the same height. This, of course, may be due to slight misalinement of the armature and poles rather than to speed variation.

*Films No. 11 and No. 12.* These records are from the same source; that is, motor-generator set No. 11. This equipment consists of three units; one motor with two generators. These two-pole generators each have 40 slots and 320 commutator segments. Each generator unit has a single high-voltage commutator, interpoles, and a compound field. The 7500 volts is obtained by connecting these two 3750-volt units in series.

Analysis of these films discloses the fact that slot ripple and armature grain ripple, with a minute amount of commutation ripple, are present. Moreover, the voltage generator supply. Here, the slot ripple preponderates by far over the grain direction irregularity. Commutation ripple can be seen here and there on the trace, superimposed on the slot pulsations; but with regard to amplitude, it is of minor importance. Film No. 18 was recorded with the filter in the high-voltage generator supply circuit, and here the slot ripple has been almost entirely eliminated, but the grain direction ripple still persists. It should be noted that the no-load and full-load traces on Film No. 18 are somewhat dissimilar. At no-load, the grain direction component can be noticed as four pulsations per revolution. These same four grain pulsations also appear on the full-load trace in Film No. 18, but they are superimposed on

another variation that does not occur in the no-load trace.

This latter variation at full load may be attributed to the misalinement of the motor and generator shafts.

### Conclusions as to Desirable Features in D-C. Generators for Minimizing Voltage Irregularities

This investigation of voltage irregularities has shown that it is desirable to have the following features inherent in d-c. high-voltage generators:

1. The armature laminations should have their grain oriented in various directions normal to the shaft, so as to cause the armature reluctance to average to uniformity. In the case of circular punchings for small machines, this orientation of grain will permit cross flux from one plate to another, due to permeability difference, with the accompanying slight increase in eddy-current losses, but this will not be of a serious nature. For segmental punchings as used on large generators, the grain direction should parallel the teeth, on account of the high tooth flux densities used.

2. Proper design as regards pole coverage and armature tooth and slot dimensions should be employed in the physical make-up of the generator so as to eliminate slot ripple.

3. All generators to be used as high-voltage d-c. supplies should have interpoles, as the characteristics of machines so equipped are much better than the non-interpole machines both from the standpoint of commutation and voltage irregularity.

4. Motor-generator sets should have a coupling of such design and characteristics as not to produce side shifting of the generator armature under fluctuating or continuous load. Moreover, the coupling should not affect the generator speed and cause periodic fluctuations therein.

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**Abridgment of**

# Shunt Resistors for Reactors

BY F. H. KIERSTEAD,* Member, A. I. E. E. H. L. RORDEN,* Associate, A. I. E. E. and L. V. BEWLEY* Associate, A. I. E. E.

***Synopsis.***—*The object of this paper is to present the results of an investigation to determine the effect of resistors shunting current limiting reactors, on the impulse behavior of the typical system employing them. The typical system is reduced, without loss of essential generality, to a comparatively simple analytic network; and the impulse behavior of this network is then calculated mathematically. These calculations are adequately supported by test results with impulse generator and cathode ray oscillograph, both in the field and in the laboratory, and accurate agreement established. Methods are developed and illustrated for taking into account incident waves, such as those due to lightning, of arbitrary shape. Under the most unfavorable condition of wave shape and circuit conditions, voltages approaching four times that of the incident wave may be built up at the bus by reflections and oscillations. In general, through the use of a shunting resistor, of proper value, three beneficial results are obtained: (a) Oscillations are completely eliminated, thereby limiting the maximum voltage which can occur on the bus to never more than twice that of the incident wave. (b) The initial rise in voltage on the line side of the reactor, due to positive reflections, is reduced and can be held down to the final value corresponding to the tail of an infinite rectangular incident wave. (c) The internal oscillations in the reactor itself can be eliminated, and the voltage distribution improved. The extent to which these improvements can be realized, under a wide range of possible operating conditions, is discussed and illustrated in this paper. With some combinations, the improvements are very great, while for others, there is no appreciable gain. The criterion for utilization of shunt resistors is,—will the elimination of oscillations and the reduction of positive reflections, under the most unfavorable possible operating condition which can be experienced on a given system, be worth the cost?*

* * * * *

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## Introduction

THIS paper is part of an extensive investigation of lightning waves on transmission lines, which has been under way for a number of years under the general direction of F. W. Peek, Jr.

There has been a wide divergence in the opinion of engineers as to the relative merits of resistors shunting current limiting reactors. Some have ascribed to them the property of reducing transient voltages, which apparatus has to stand, while others have felt they do not reduce these transients and, in some cases, may actually increase the voltage stresses in connected apparatus. The purpose of the investigation described in this paper was to determine by an analytical treatment of the apparatus and circuits involved, what benefits or detriments should be expected from the use of resistors.

The presentation of this investigation takes the following form:

I. The typical system using current limiting reactors is considered.

II. The general analytic network of the typical system is resolved into its generalized impedances and the progress of an incoming or incident wave through these impedances is outlined.

III. The equivalent circuit of the network is described.

IV. The shape of the incident waves used in the calculations is defined and the mathematical methods of dealing with them are described.

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*Presented at the North Eastern District Meeting of the A. I. E. E., Springfield, Mass., May 7-10, 1930. Complete copy upon request.*

V. Formulas for calculating the effects of the incident wave on the typical system are given, together with the results of calculations on this system.

VI. Experimental results are given which show that the effect of waves upon such systems may be accurately calculated.

VII. The effect of a resistor on the internal distribution of voltage in a reactor is discussed and experimental results are shown.

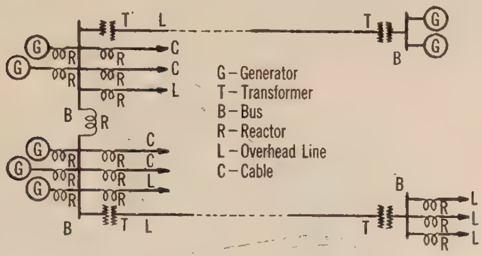


FIG. 1—SINGLE LINE DIAGRAM OF A TYPICAL SYSTEM USING CURRENT LIMITING REACTORS

VIII. General conclusions are drawn.

## I. TYPICAL CIRCUIT USING CURRENT LIMITING REACTORS

In a typical system in which reactors are used, as shown in Fig. 1, the apparatus and circuits may be

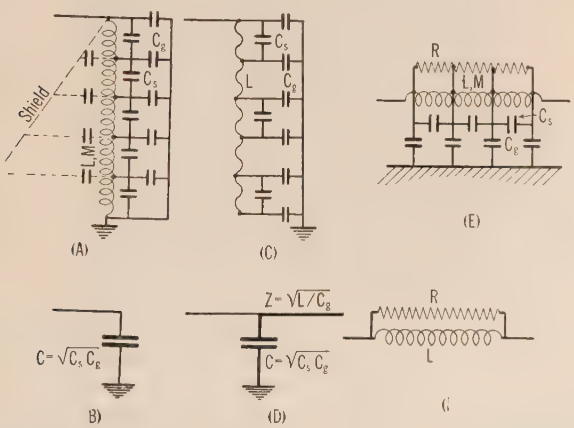


FIG. 2—EQUIVALENT CIRCUITS OF TERMINAL APPARATUS TO LIGHTNING SURGES

A. Transformer, ideal.
B. Transformer, approx.
C. Rotating machine, ideal.
D. Rotating machine, approx.
E. Reactor with shunt resistor, ideal.
F. Reactor with shunt resistor, approx.

represented for mathematical treatment of impulse voltages as follows:

1. Overhead lines by surge impedances of 300 to 600 ohms.
2. Underground cables by surge impedances of 30 to 90 ohms.
3. Station busses by capacitances to ground.
4. Terminal equipment by the equivalent circuits shown in Fig. 2. The use of a capacitance as the equivalent circuit of a transformer, has been established theoretically and experimentally. The equivalent circuit for a generator was determined by E. W. Boehne, and will be discussed in a paper by him to be presented at the Summer Convention. Reactors behave practically as pure inductances in their external effect on traveling waves.

## III. EQUIVALENT CIRCUIT OF THE NETWORK

The circuit that has been used (as the equivalent of the network of a typical system in which reactors are placed) in the calculations of this investigation

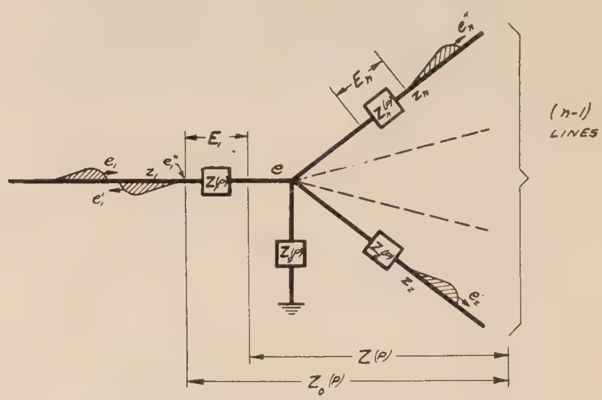


FIG. 3—GENERAL NETWORK

is shown in Fig. 4, and its complete solution is given in Appendix II. In this figure, the surge impedance $z_1$ is the feeder (either overhead line or underground cable) which carries the oncoming incident wave $e_1$. This feeder terminates at the bus in a reactor unit of inductance $L$, shunt resistance $R$, and an effective series resistance $r$ (due primarily to the transient skin effect of the lightning wave). The total equivalent capacitance to ground, due to all terminal equipment (including transformers, generators, and busses) has been lumped as a single capacitance $C$. All outgoing feeders, as well as the effective surge impedances of rotating

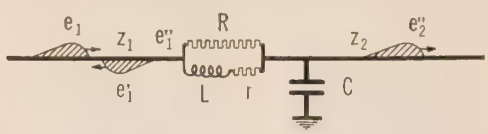

FIG. 4—EQUIVALENT CIRCUIT OF LINES, REACTOR AND TERMINAL APPARATUS

apparatus, have been lumped as a single outgoing feeder of surge impedance $z_2$. When the incident wave, $e_1$, strikes the junction, a part $e_1'$ is reflected back and a part $e_2''$ passes on to the outgoing feeders as a transmitted wave.

The formulas and methods given in the complete copy of this paper for the calculation of reflected and transmitted voltages apply for an incident wave having any of the shapes given in Fig. 5. The computations of reflected and transmitted waves have been based on incident waves of shapes similar to the 1st, 2nd, and 6th waves in Fig. 5.

The derivation of the equations which were used in making these calculations is given in Appendix II.

Curves drawn from values in Table I of the complete paper are plotted in Figs. 6 to 17 inclusive. They give the total voltage on each side of the reactor ($e_1'' = e_1 + e_1'$ and $e_2''$) resulting from the incident wave $e = \epsilon^{-at}$ where $a = 0$. Also on Figs. 6, 7, 8, 12, and 13, are drawn for comparison $e_1''$ and $e_2''$ corresponding to the incident wave $e_1 = 4\ (\epsilon^{-0.1t} - \epsilon^{-0.2t})$. This wave has a seven-microsecond front, a crest value of unity, and the

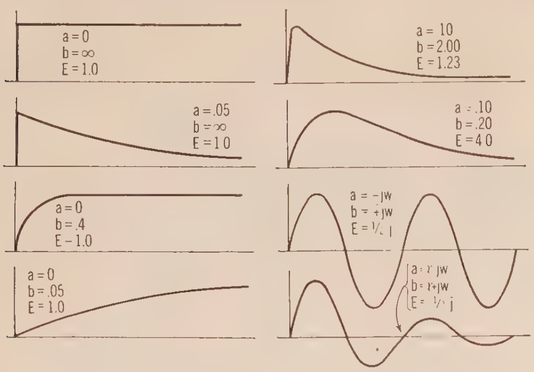


FIG. 5—EMPIRICAL WAVE SHAPES GIVEN BY $e = E\ (\epsilon^{-at} - \epsilon^{-bt})$

tail decreases to ½ of the crest value in 20 microseconds. The data used in plotting these latter curves were taken from Tables II and III. They are plotted below the zero axis to avoid interference with the waves corresponding to the rectangular incident wave.

The waves plotted on the left-hand side of the figures give the voltages obtained with no resistor ($R = \infty$) shunting the reactor while those on the right

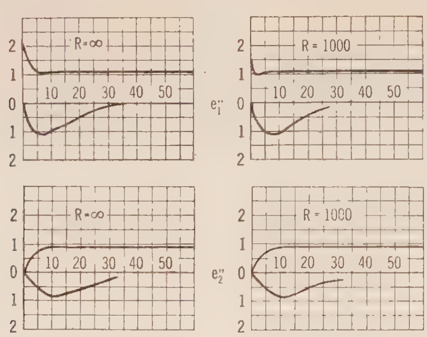


FIG. 8—$r = 100$, $L = 0.002$, $Z_1 = 400$, $Z_2 = 400$, $C = 0.005 \times 10^{-6}$

hand side correspond to a 1000-ohm resistor shunting the reactor.

*Figs. 8 and 9.* These cases are similar to that of a bus system with overhead feeders. In such a system, $z_2$ would have reactors in it and would represent several feeders in parallel. It is believed that the inaccuracy due to not having reactors is partially offset by the use of the surge impedance of only one line. The fact that the transmitted voltage is low and that its wave front is not as steep as that of the incident wave (due to the shunt capacitance), in a measure justifies this simplification of the circuit.

The improvement due to the resistor is chiefly on the line side of the reactor. The voltage at this point is approximately 75 per cent of the voltage without the resistor when the incident wave is rectangular. The improvement is less for sloping waves, being inappreciable for the 7-microsecond wave as is shown by the waves below the zero axis in Fig. 8. The actual improvement depends on the steepness of the waves which occur in practise.

*Fig. 13.* This figure applies to the case of a single cable terminating at a bus. Substantial oscillations occur in the transmitted wave causing it in the case of Fig. 12 to rise 3.37 times the incident voltage and 3.77 times for Fig. 13. The reductions effected by the resistor for Figs. 12 and 13 are 23 per cent and 47 per cent respectively when the incident wave is rectangular and a much smaller amount for the 7-microsecond incident wave.

*Fig. 17.* This case represents the usual bus system with underground cable. Here again, the gain due to the resistor is negligible due to its high resistance.

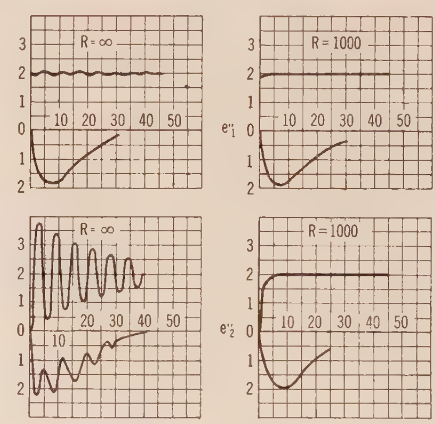


FIG. 13—$r = 100$, $L = 0.002$, $Z_1 = 50$, $Z_2 = \infty$, $C = 0.0005 \times 10^{-6}$

With a resistor of 50 ohms, the gain would be large, as there would be no appreciable reflection and consequently, the line voltage would be very little higher than the incident wave. In other words, the voltage on the line side of the reactor would be decreased by the resistor from twice the incident voltage to not more than 1.1 times the incident voltage.

## VI. EXPERIMENTAL RESULTS

In order to check the accuracy with which the transmitted wave, due to a given impulse may be calculated, tests were made, using the circuit shown at the top of Fig. 18 of the complete paper. The results of these tests are tabulated in Table IV. The tested waves are shown by the oscillograms in Figs. 19, 20, 21, and 22. These waves are reproduced by curves below the oscillograms with the calculated voltages shown by points plotted on the curves.

Tests 5 and 6 represent an impulse striking a reactor in series with a transformer at the end of a line. The results of Tests 5 and 6 are shown in Figs. 21 and 22. When the reactor is not shunted by a resistor, the transmitted wave is oscillatory and is 63 per cent greater than the wave on the other side of the reactor; while with a 1200-ohm resistor, the wave is not oscillatory and is only 13 per cent greater than on the other side. It will be seen from the calculated points plotted on Figs. 21 and 22, that the calculations agree closely with the tests.

## VII. The Effect of a Resistor on the Internal Distribution of Voltage in a Reactor

In Appendix III are given formulas for calculating the internal distribution of voltage in a reactor both with and without a resistor in shunt. These formulas show that with no resistor, the distribution consists of a very complex oscillation superimposed on the linear distribution which represents the final state, but that with a properly chosen resistor, the oscillation is eliminated.

Tests were made to determine the internal distribu-

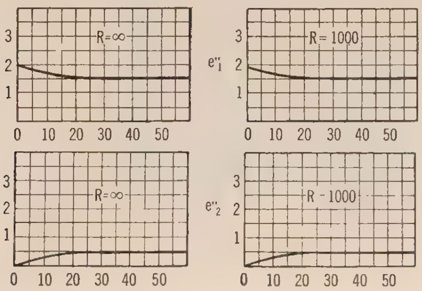


Fig. 17—$r = 100$, $L = 0.002$, $Z_1 = 50$, $Z_2 = 50$, $C = 0.0005 \times 10^{-6}$

tion of voltage in a reactor of 0.002 henrys inductance with an applied wave of 50 kv. as follows:

1. Reactor not shunted by a resistor.

2. Reactor shunted by a 1000-ohm resistor with six intermediate points connected to the corresponding intermediate points of the reactor.

3. Reactor shunted by a resistor having the characteristics shown in Fig. 24 and connected to intermediate points as noted under 2.

The circuit used in these tests is shown by the lower diagram of Fig. 18.

The results of the tests are shown in Figs. 25 and 26. The oscillograms in Fig. 25 give the voltage across the reactor and also the voltage from the bottom terminal of the reactor to each of the points where the resistor was connected to the reactor. They show that there is quite an appreciable internal oscillation when the reactor is not shunted by the resistor but that the oscillation is eliminated when the reactor is shunted by the resistor.

## VIII. Conclusions

The following general conclusions can be drawn from the calculations and tests:

1. If an impulse passes into a circuit as shown in Fig. 4, where $z_2$ is very high or infinite, an oscillation results which gives rise to voltages which approach four times the incident voltage as a limit. These oscilla-

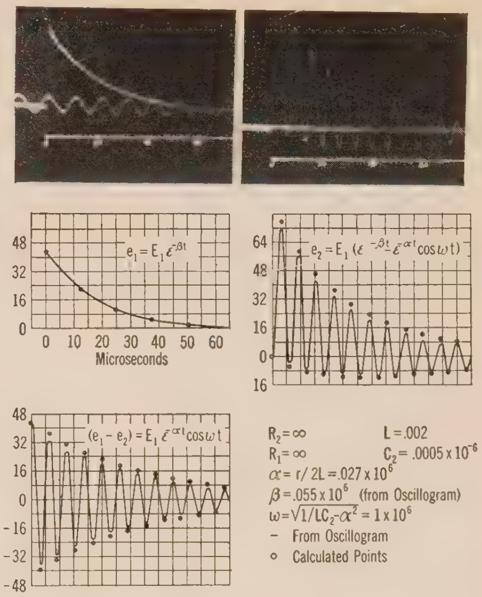


Fig. 21—Impulse Tests on Reactor—No Shunt Resistor

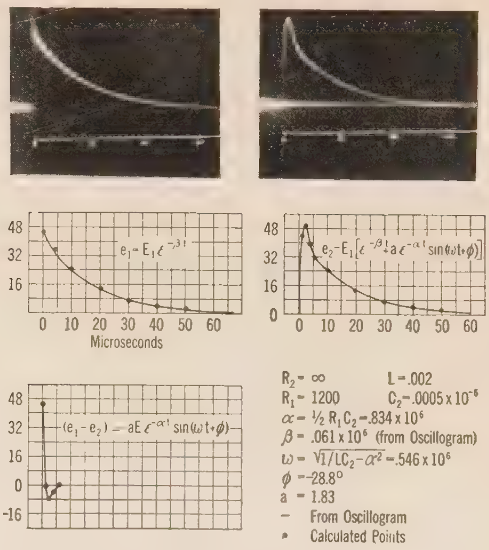


Fig. 22—Impulse Tests on Reactor—With Shunt Resistor

tions are entirely eliminated by shunting the reactor with a resistance approximately equal to the surge impedance $z_1$. Then the voltage rise is due to reflection and in the limit approaches two times the incident voltage.

2. If $z_2$ is not higher than $z_1$, no oscillations will occur, and the transmitted voltage will be equal to or lower than the incident wave. Here the advantage of

the resistor is in lowering the reflected voltage on the line side of the reactor. In order to do this effectively, the resistance should be equal to or lower than the surge impedance ($z_1$) of the line. Then the reflected voltage will be very low and the maximum voltage on either side of the reactor will not be substantially greater than the incident voltage.

3. If a substantial voltage occurs across a reactor (due to an oscillation or to the reactor acting as a reflection point), the transient voltage that the line or bus has to stand as a result of the disturbance, is always reduced by shunting the reactor with a resistance of the proper value. Conversely, if shunting the reactor with the proper resistance does not reduce the transient voltage that the line or bus has to stand, then it is because these transients are of such low frequency or such sloping wave fronts that they do not produce an appreciable voltage across the reactor.

### General Discussion

There are two essential conditions to be met in the design of shunt resistors for reactors. First, in order to give effective protection against lightning or other high-potential surges, the resistance should not be more than 400 ohms for overhead lines or 50 ohms for underground cables. Second, the resistor must not overheat when the reactor with which it is used is undergoing short circuit.

To meet the latter condition, a high resistance is nec-

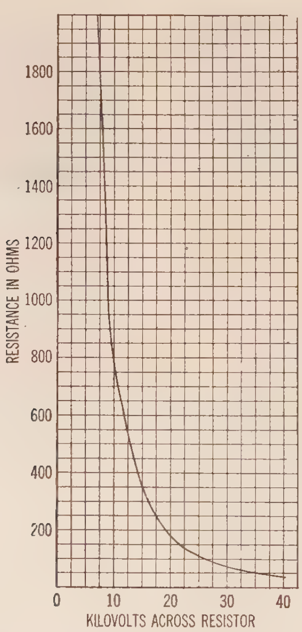


Fig. 24—Voltage—Resistance Characteristic of Thyrite

essary. The rate at which energy is absorbed by the resistor is $P = E^2/R$ where $E$ is the voltage across the resistor and $R$ is its resistance. Thus in a 13,800-volt circuit, the voltage across the reactor during short circuit is $13{,}800/\sqrt{3} = 7980$ volts, and if the reactor is for use with an underground cable, the resistor (in order to have maximum effectiveness in reducing transient voltages) should have a resistance of not over 50 ohms. The energy absorbed would then be at the rate of $\dfrac{7980^2}{50 \times 1000} = 1274$ kw. A resistor capable of absorbing so much energy without over-heating would be prohibitive in cost. For these reasons, a lower resistance for high voltages than for low voltages is essential. For instance, if the resistance is 600 ohms

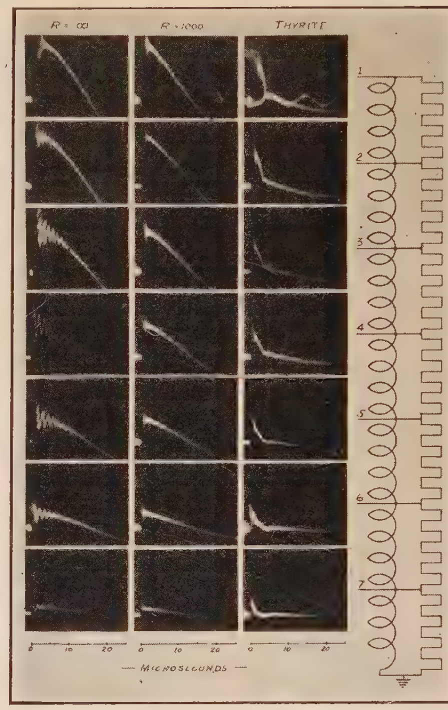


Fig. 25—Oscillograms showing Internal Voltage Distribution in Reactors

with 7980 volts r. m. s. across it and 50 ohms for 35 kv. crest (which is approaching the danger zone for 13.8 kv. circuits) it has the proper characteristic for the above case. In Fig. 24 is given the voltage—resistance curve of the type of resistor used. It will be noted that it has the required characteristics.

## ELECTRIC EYE DETECTS GAS IN HOLLAND TUBE

Not only is every motor car which passes through the Holland Tunnels counted electrically, but a new application of the same electric eye, or photo-electric cell, has now been installed to give warning of dangerous exhaust gases from automobiles.

Warm exhaust gases cast faint shadows across a beam of light, and the minute change is recorded by the sensitive photoelectric cell. This, in turn, by the change of current on the circuit, registers on a dial in the superintendent's office and enables the man in charge to turn a switch to speed up suction fans to carry the gases away.—*Transactions I. E. S.*

Abridgment of

# Automatic Power Supply for Steel Mill Electrification

BY ROBERT J. HARRY[1]

Non-Member

*Synopsis.—In the production of steel, the use of electrical energy is growing rapidly. This paper outlines the present operating conditions in the Monongahela Valley System of the Carnegie Steel Company. The use of automatic switching for certain portions of this power supply has proved both economical and satisfactory.*

* * * * *

WE read and hear so much these days of the extensive electrification programs of the public utilities that (electrically speaking) we are apt to overlook what is going on inside the fences which surround the modern steel mill. The utilization of the by-products incidental to the manufacture of steel,—such as gas from the blast furnaces, coke dust, tar, etc.,—provide a source for the generation of electricity more than sufficient to meet the demands of the steel manufacturers. In most plants, all of the available sources of heat have not been utilized, owing to the fact that the demand is not so great as the supply. With the increasing demand for power, we shall see all of the available sources used and waste heat boilers will be installed wherever any hot gases are found to be passing out to the surrounding atmosphere without giving up their precious B. t. u.

During the past few years we have seen electric drives replacing steam drives, both for main rolls and auxiliaries, so that we find many instances where a quarter of a million motor horsepower is installed in a single steel plant.

In the next few years, we shall see electricity employed in a new field which will require every available kilowatt that can be produced. The author refers to heating steel by electricity. Statistics show that this method of heating is cheaper when done under the proper conditions. It is the purpose of this paper to discuss the power system which supplies the five large U. S. Steel Corporation Steel plants in the Monongahela Valley about 10 mi. above Pittsburgh. These plants are Homestead Steel Works, Edgar Thompson Steel Works, Duquesne Steel Works, National Tube Company and the Clairton Works.

Until about a year ago, only Homestead, Edgar Thompson, Duquesne and National Tube Company were electrically connected. This connection consisted of a pair of 500,000-cir. mil circuits at 6.6 kv. Due to the great distances between plants, the transmission for this voltage was not very efficient, and as a result, it was impossible to transmit the required amounts of power without an abnormal voltage drop. The ability to help out an adjacent plant in case of power shortage, as well as the much better load factor that could be obtained by operating with all plants tied together, presented an economic advantage; therefore about three years ago it was decided to rebuild the system and extend it so as to include the Clairton works.

On account of this tie line operating in an industrial section where conditions are not favorable for insulation, it was some time before an operating voltage was decided upon. At first it was recommended that 22 kv. be adopted, but finally it was decided to use 44 kv. With this voltage efficient transmission can be obtained for even greater distances than at present encountered. While higher voltages were considered, it was agreed that 44 kv. was as high as could be operated with any guarantee of continuous service. The successful operation of this line leads us to the conclusion that higher voltages could be successfully employed.

Two circuits were installed, and in order to secure continuity of service under the worst conditions, it was decided to use No. 0000 copper. This enables either line to transmit at high efficiency the capacity of the largest unit on the system, which is 15,000-kw. This contingency could arise at three of the plants where 15,000-kw. units are installed. The transmission system could therefore meet this condition with one circuit out of commission.

Fig. 1 shows the 44-kv. transmission system as it is at present, and gives the distances between substations. When the two circuits are in commission, the system is always operated with the knife switches, which connect up the two 44-kv. lines on the high-voltage side of the transformer bank, in the open position. These switches are installed for emergency and single-line operation.

The neutral on the 44-kv. side of the transformers is solidly grounded at all substations. The five substations are equipped with a total of nine 9000-kv-a. three-phase Y-delta transformers. Two of these transformers are located at Homestead, two at Edgar Thompson, two at Duquesne, two at Clairton, and one at National Tube Company. The transformer capacity at the various plants was determined by the shortage which would be created by the failure of the largest generating unit in the plant. These transformers are equipped with tap-changing devices with conveniently arranged mechanism for changing the three phases

1. Of the Alliance Machine Company, Alliance, Ohio. Formerly with the Carnegie Steel Company

*Presented at the Summer Convention of the A. I. E. E., Toronto, Ont., Canada, June 23-27, 1930. Complete copy upon request.*

simultaneously, and are located close to the floor. An indicating dial is also installed, as well as provision for locking in any tap position. The oil circuit breakers must be open during tap changes. It was not considered necessary to add to the cost of equipment by instaling tap-changing equipment which could be

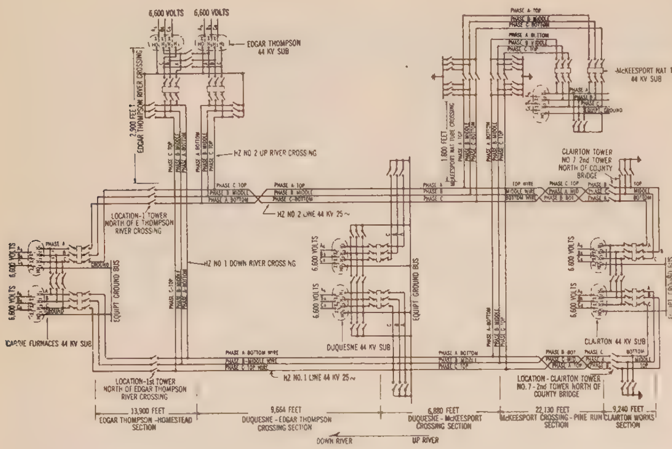

FIG. 1—44-KV. TRANSMISSION SYSTEM OF THE MONONGAHELA VALLEY—CARNEGIE STEEL COMPANY

operated under load. The high-tension bushings have a normal rating of 73 kv. with a dry flashover value of 240 kv. and wet flashover of 200 kv. The low-tension bushings have a normal rating of 25 kv. with a dry flashover value 100 kv. and wet flashover of 40 kv. All of the transformers are so designed that blowers can be installed to increase the rating, but only at Homestead was this extra equipment actually installed. With the blowers in operation supplying 5000 cu. ft. of air per min. at three-ounce pressure, and the temperature of the atmosphere 40 deg. cent., a 25 per cent continuous rating above normal, or 11,250 kv-a., is guaranteed. With a larger blower, much greater capacity can be obtained. The blowers were installed on the Homestead transformers to meet the conditions arising from the shut down of one of the 15,000-kw. turbines when load conditions were at a maximum.

In order to satisfy the telephone company engineers, it was necessary to transpose the 44-kv. lines between the Duquesne and Clairton works where the power line paralleled the telephone lines.

Three of the substations are typical outdoor type, while two are indoor type. It has been found that in order to prevent the rapid deterioration of the radiators, it is necessary, where the transformers are located outside near blast furnaces, to resort to frequent painting. This may be a good application for rustless steel.

Before the five plants were connected together, it was necessary to make a study of short circuits in each plant to ascertain the proper size of circuit breakers. In some of the plants, radial feeders with proper current limiting reactors are installed, while at other plants, loop circuits are employed. In order to reduce the short-circuit values to a point where the circuit breakers could meet the thermal and interrupting capacities, it was necessary at some of the plants to insert reactors in the station bus.

At the Homestead Works, a loop system is in operation. When completed, it will be as shown on Fig. 2. At the Carrie furnaces, only two turbo generators are installed at present, although provision has been made for a third unit. The oil circuit breakers have sufficient capacity to meet the proposed increase in generating capacity. Reactors having a continuous capacity of 2000 amperes are installed in both front and back busses, and oil circuit breakers installed to short-circuit the reactors when operating conditions require. The size of this equipment permits the transfer of the entire capacity of a 15,000-kw. generator to any part of the bus for distribution either through switch or reactor. Under normal operating conditions, the feeder circuits are so arranged that very little power is transmitted through the bus reactor.

Reactors were installed at strategic points in the loop system so that only that portion of the system in which the fault occurs is affected, sufficient voltage being maintained in the other parts of the system to prevent losing the synchronous load. While the above reason would be sufficient to warrant the installation of reactors, their economic value is of considerable importance. The reactors installed in the loop stations between the bus and feeder circuits permit the use of small oil circuit breakers with the same margin of safety that obtains

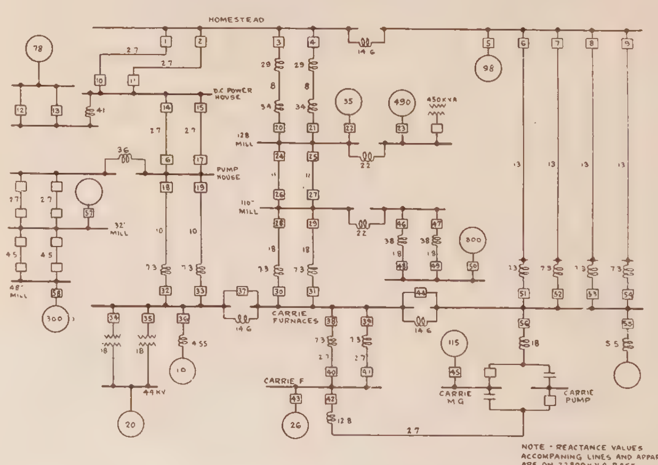

FIG. 2—SINGLE-LINE DIAGRAM OF HOMESTEAD & CARRIE FURNACE WORKS OF CARNEGIE STEEL CO. 6.6-KV., 25-CYCLE

with the use of larger breakers on the other side of the reactor. This can be illustrated by the fact that the loop bus at the d-c. power house is equipped with breakers having an OCO + OCO rating of 36,000 amperes at 6600 volts, while the feeder breakers on the other side of the reactor have a big safety factor with an OCO + OCO rating of 8500 amperes at 6600 volts. When it is considered that there are 22 small feeder

breakers installed in this location, the economy made possible by the use of reactors is very apparent. The reactors also prevent the extremely heavy currents with their resultant stresses from getting to the small feeder circuits and equipment connected to them.

The loop circuits are of overhead construction, located on towers, and involving two river crossings. The towers at the loop stations are of special design, and in addition to supporting the lines, have a three-story building with a 30-ft. by 25-ft. floor area located in

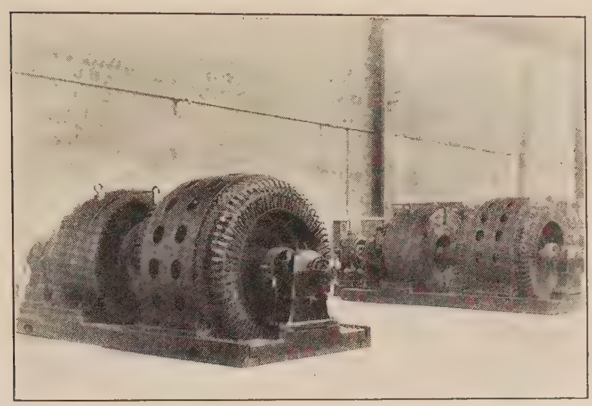

Fig. 7—Two 1500-Kw. Motor-Generator Sets in the Homestead Substation

the bases. The lightning arresters are outside valve type and are accessible from the roof. The oil circuit breakers are located on the third floor, the reactors on the second floor, and the ground floor provides sufficient space to house power and lightning transformers.

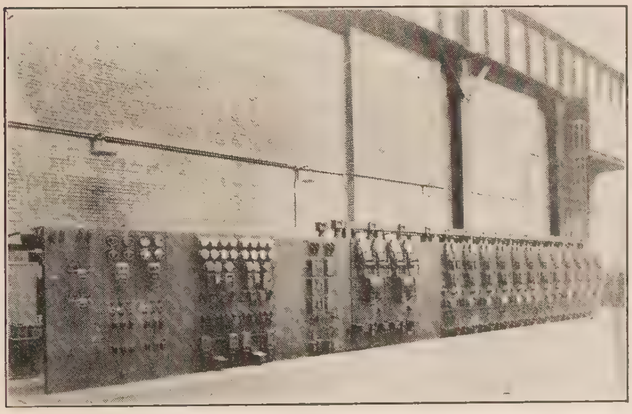

Fig. 8—Automatic Switchboard for the Control of the Motor-Generator Sets

The third set is now in operation, the control boards replacing the blank panels in the picture

The oil circuit breakers are of the metal-clad lift type which permits of unit assembly at the manufacturers' plant, and provides for easy additions in the field. All substations can easily take care of the distribution of 10,000 kw. which provides for future installation. In the substations, 32-volt storage batteries are installed for tripping the oil circuit breakers and to provide a source of light in case of power failure. Since nothing would be gained by closing the breakers before power was restored, a motor-generator set with automatic switchboard to provide 250 volts direct current for closing the breakers was installed. This motor-generator set is small, and 250 volts emergency is obtained in a few seconds after the 6600-volt lines are energized.

At the New Structural Mills, an automatic substation is installed. It consists of three 1500-kw. motor-generator sets operating at 500 rev. per min., the motor being of the standard synchronous type arranged for compensator starting and the generator being compensated shunt-wound.

The reason for making this substation automatic was to reduce operating costs. These sets, located in the large building, are shown in Fig. 7. The figure shows but two sets, the third set having been added recently. Provision was made in the switchboard shown in Fig. 8 and foundations provided for this contingency. This

Fig. 9—Underground Installation of Mill Table Controllers

room, a general view of which is shown in Fig. 10, also contains seven main roll drive motors, with their motor-generator sets and auxiliaries. The duties of the two men employed in this room require them to spend considerable time in the basement where the air conditioning equipment,—fans, truck type oil circuit breakers, etc.,—are located; and they are therefore unable to spend much time at the motor-generator sets. Because of this, it was considered safer to depend on the automatic features,—which are continually on the alert and ready at all times to do their assigned duty,—rather than upon an operator who may or may not be on the scene when trouble occurs to the equipment.

There were many automatic features which could have been installed, but which were not on account of the added cost and complications not warranting their installation; also, because two men are always in the building.

The substation is equipped with the following features:

1. Individual, truck-mounted, line-starting and running oil circuit breakers and starting auto-transformers are provided for each motor-generator set, and one common cell housing for the necessary potential transformers is provided for all sets.

2. The normal d-c. control is taken from a constant source.

3. Push-buttons are used to start all units.

4. After the unit has attained synchronous speed, a three-element regulator balances the generator voltage against line voltage and then connects the generator to the bus. The regulator then operates to maintain constant voltage on the d-c. bus. A load-limiting element regulates the load that can be taken from the generator.

5. The d-c. feeders open only on short circuit and reclose automatically after a suitable time element and the removal of fault.

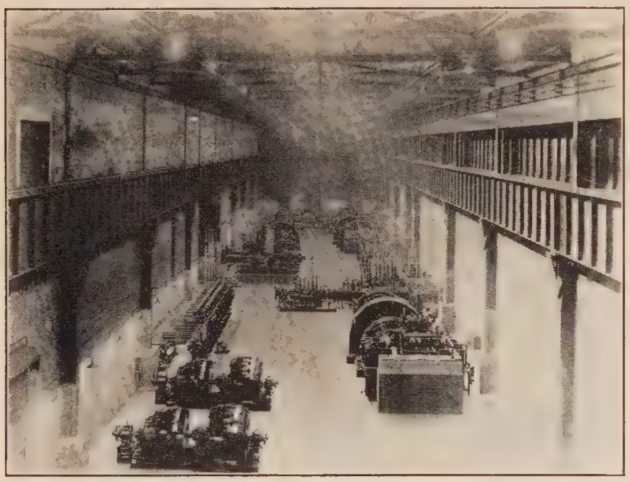

Fig. 10—General View of Automatic Substation at Homestead

Two of the three present sets with automatic switchboard may be seen in left foreground

6. Equipment is installed to protect against:

(a) Single- and reversed-phase starting; (b) a-c. undervoltage; (c) a-c. overload; (d) field failure; (e) wrong polarity; (f) reverse power; (g) overheated motor winding; (h) hot bearings; (i) d-c. and a-c. ground protection; (j) overspeed; (k) d-c. overload; (l) overheated starting compensator; (m) overheated generator windings; (n) undervoltage connection to d-c. bus.

The results obtained from more than four years of operation have been entirely satisfactory and we do not in any way regret the decision in favor of the automatic equipment. To date, no automatic features have been discontinued and no failures or emergencies have made necessary the installation of additional protective or automatic equipment. While some minor troubles were experienced when the station was first put into service, after all adjustments had been made the reliability of the equipment has met our most optimistic expectations. Some faulty operations of the feeder breakers have occurred where the acceleration currents drawn by large motors approximate short-circuit conditions, and the impulse coils on the feeder circuits find it very difficult to differentiate between these conditions when they have practically the same steep wave front.

One item which must be kept in mind when making installations of this size, is the bracing of the d-c. bus bars. Bus short circuits which occur on feeder circuits close to the substation produce tremendous stresses which will destroy the bus structure unless very rigidly braced to withstand the stresses.

In cases where one station is tied to one or more other substations by suitable tie lines, these tie lines should be equipped with high-speed breakers. These breakers should have a very definite tripping current which will permit sending over these lines all the current the station can in safety put out and provide for normal interchange of power. In case of substation outage, currents of much greater magnitude would be involved which would separate the good substations from the faulty one before the standard circuit breakers would have time to function. This equipment would prevent many of the d-c. total outages.

It has been found that where electric equipment is isolated from the mill equipment and installed in buildings where it can be kept clean, that little trouble can be expected. This is true not only of substation and mill motor equipment, but holds equally true for auxiliary equipment. Where possible, mill auxiliary controllers are grouped and installed in houses or in tunnels directly under the equipment. Fig. 9 shows a typical installation of a group of controllers for mill tables. This type of installation provides for easy inspection and maintenance.

The reliability of the equipment entering into the construction of the modern automatic substation, and the greater protection obtained from the use of modern relays which possess almost human intelligence and indefatigable alertness, will result in the installation of a greater number of the equipments in the steel plants.

## ALUMINUM'S NEW ROLE

As structures increase in size and as accelerations and decelerations grow greater, the importance of the relations of strength and weight of materials of construction becomes more evident. The Aluminum Company of America has recently commenced the operation of a mill for rolling strong but light structural shapes in duralumin. In *Mechanical Engineering* for May is a brief description of the plant which is located at Massena, N. Y., and a discussion of the new role which aluminum is prepared to play as an engineering material.

# Coordination of Insulation as a Design Problem

BY G. D. FLOYD*

Member, A. I. E. E.

***Synopsis.**—The factors having influence on insulation design of transmission line and station are briefly reviewed, and it is pointed out that the progress of the art does not yet allow of close design of the insulation structure for insulation strength.*

*The prominent part played by the lightning arrester is stressed, and the fact that it has a marked effect on the coordination of station insulation.*

*Examples of a typical 110-kv. station where no coordination was made, and of a 220-kv. station where a deliberate coordination was attempted, are given, as well as the experience obtained with each.*

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## INTRODUCTION

INSULATION design, both for the transmission line and for the various members of the station insulation, has reached its present status largely through experience. The behavior of insulation, when subjected to electric stress, is probably less understood, even today, than any other electrical phenomenon, and as a consequence it has been necessary to apply the acid test of operation in order to determine the suitability of insulation design for the service intended. The almost total lack of knowledge of the magnitude and character of the over potentials appearing on a system has only added to the difficulty of rational design.

Overhead transmission at voltages of 110 kv. and above and for distances of the order of 100 miles and greater has been general for a number of years, and the service given by these systems has been, generally speaking, quite good, from an insulation standpoint, considering the lack of knowledge of the behavior of insulation. Where weakness has developed, that part of the insulation structure has been strengthened, and therefore, unconsciously perhaps, a rational coordination of the various members of the insulation structure to the stresses, has resulted.

Several factors appear to have had an influence on the present condition of affairs. In the first place, there has been the desire for increased service security, and consequently attempts to make important lines lightning proof. The result, in many cases has been increase in the line insulation without corresponding increase in station insulation, so that the coordination accomplished through experience has been all upset, —sometimes with disastrous results.

A second factor has been the recent intensive study of the behavior of insulation when subjected to surges, and the parallel study of the magnitude and character of surges appearing upon transmission lines. The data obtained are by no means complete, and conclusions are often contradictory, but the general result has been to make possible, for the transmission line itself at least, a design which can make the line practically lightning proof, if desired. The data for bus supports and station inductive apparatus are not nearly so complete, so that the tendency naturally is, to design the line insulation to give a lightning-proof line, and to assume that the station insulation is satisfactory, in the absence of data to the contrary.

A third factor calling for close study of insulation requirements is the recent increase in practical system voltage to 220 kv. The natural tendency here has been to keep down capital cost of transformation by solidly grounding the 220-kv. neutral and using graded insulation on the transformer. The only justification for the higher system voltage is a decrease in over-all transmission cost, so that any means of accomplishing this with safety is desirable. On the other hand, the amount of power per circuit carried on these high-voltage lines has made it imperative that the line insulation be sufficient to keep outages from flashover to the lowest possible number. These tendencies are in opposite directions, so that some means of coordination must be arrived at. The most direct method would appear to be to increase the transformer insulation strength, but other means are available, some of which are given in detail later.

## FACTORS GOVERNING DESIGN

*A. Transmission Line.* The overhead transmission line is subject either to lightning, switching surges, and surges due to arcing grounds, or to the latter two only. The magnitude of the maximum lightning surge has been quite definitely established to be several times that of the switching surge, so that a line which has ample insulation to withstand lightning surges can usually be considered as safe against all surges that may occur of whatever nature.

The magnitude of the lightning surge is proportional to the average height of conductor above ground if the surge is induced, and the voltage is higher, if no ground wire is used, for the same average height of conductor. The maximum surge potential that the line may assume is also limited to the insulation strength of the insulators for the surge in question. This in itself, is a variable quantity, due to the variation in impulse ratio of the insulators. This applies whether the surge is a so-called direct hit, or an induced surge.

The insulation strength of the string along its length has been determined with some degree of accuracy by laboratory tests, and varies greatly with the duration of the surge, increasing as the duration decreases. The insulator string is therefore, to some extent, self-protecting, as the surges of highest magnitude are usually also of short duration. Fig. 1 shows this clearly; also the effect of grading rings.

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Minimum insulation strength is not always developed along the insulator string, and arcs sometimes strike from the line end of the string to the tower. The present tendency towards increasing the insulation on existing lines will increase this possibility, and it should be kept in mind when increase in insulation of the line is contemplated.

Table I has been compiled from data on 110-kv. and

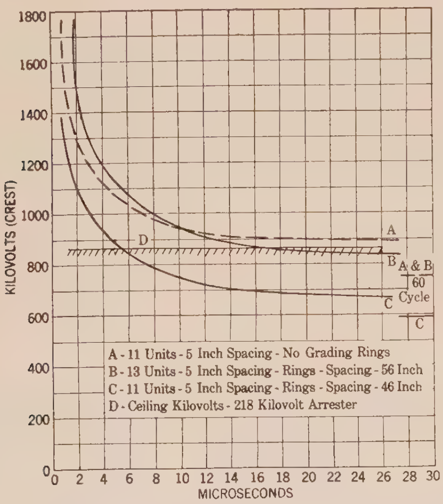


Fig. 1—Kilovolt Flashover-Duration Curves for Spillway Gap

220-kv. lines of the Hydro-Electric Power Commission of Ontario, and shows the estimated insulation strength of the lines, at commercial frequency.

TABLE I

| Line | Average height of top conductor | No. of insulator units of 5 inch spacing | 60 Cycle flashover Dry | 60 Cycle flashover Wet |
|---|---|---|---|---|
| | feet | | kv. | r. m. s. |
| Pelham-St. Thomas steel tower | 62 | 9 | 470 | 340 |
| St. Thomas-Windsor steel tower | 50 | 8 | 420 | 310 |
| Niagara-Dundas steel tower | 47 | 8 | 420 | 310 |
| St. Thomas-St. Clair wood pole | 29* | 7 | | |
| Thunder Bay wood pole | 33 | 7 | | |
| Thunder Bay steel tower | 54 | 8 | 420 | 310 |
| Ottawa-Smith Falls wood pole | 28* | 7 | | |
| Paugan-Leaside steel tower | 37* | 18 | 785 | 608 |

*Flat configuration. Paugan-Leaside line has two ground wires, all others one ground wire.

The lightning outages on approximately 1000 circuit miles of 110-kv. line equipped with suspension insulators per 100 miles per year are as follows:

1926—2.96
1927—1.25
1928—1.53
1929—2.65

The corresponding figure for the 230 miles of 220-kv. line from Paugan Falls to Toronto for one year of operation (1929) is 1.75.

When the majority of the 110-kv. lines were placed in service, nothing was known regarding the magnitude of lightning voltages to be expected, or of the impulse insulation strength of the insulators, yet these lines have been relatively immune from flashover due to lightning in districts having 25 to 30 storms per year. The outages average less than two per 100 miles per year for all 110-kv. lines, and the line insulation has never been increased.

The 220-kv. line has only been operating one lightning season, and there have been four outages, the cause of which could not be traced. Due to the fact that thunder storm areas were known to be in the vicinity of the line at the time the line flashed over, the outage has been considered as due to lightning. The insulation requirements for this line had been very carefully reviewed before specifying 18 units with 5-inch spacing. From the data available at the time, it appeared that this line should be very nearly immune from flashover due to lightning, but that to make it lightning proof appeared possible only by greatly increasing the insulation. The increase in cost would not be justified by the relatively small increase in service security.

This point cannot be stressed too strongly. It seems certain that with the present types of lines, one or two flashovers per year are bound to occur, in lightning areas, no matter what the design. The cost of towers, as well as of insulation, will increase rapidly if the number of insulator units required to make the line 100 per cent proof are specified. The increase in cost cannot be justified, unless in some very special cases of important tie lines of short length. It would appear to be better to concentrate on means whereby the line may be cleared rapidly, before the power arc can do material damage, and accept the momentary interruption. This may not involve a total interruption in many cases, because of the increasing degree of interconnection of power sources, and the fact that power demands have increased to such an extent that a number of high voltage lines are necessary to serve most districts where service security is of paramount importance.

The transmission scheme suggested in another paper[1] read at this convention can be coordinated easily as to insulation, if the scheme is found practicable from other considerations. With the arrangement suggested, it is possible to accept flashovers on any one high-voltage circuit. If these are cleared instantaneously, as seems to be easily done, so that no conductor or insulator damage occurs, there is no loss of service or increase in maintenance cost. Over insulation of lines is not necessary, and coordination of insulation, other than that normally required heretofore, is not required.

*B. Station Insulation.* Some measure of coordination of insulation strength among the various members of the station insulation structure is desirable, regardless of whether there is necessity for coordination of the station insulation with line insulation. If flashover is to occur, it is always better that the overstress be relieved at a point where least damage will result. The difficulty is that it is practically impossible to design the various members so that failure will occur for all

1. For references see Bibliography.

types of surges and all conditions at a given location, unless the insulation is so greatly weakened that there is danger of flashover for surges that would be harmless otherwise. It is not sufficient to design so that the oncoming wave will encounter slightly higher insulation as it progresses into the station because possible reflections at points of discontinuity make it necessary to have the insulation greatly stronger at such points. For example, unless the bushing at the line side of an open circuit breaker had at least twice the flashover value of the coordinated line insulation approaching the station, a surge which would just pass this insulation would be likely to cause flashover at the bushing. The assumption is made that the coordinated insulation is depended upon to restrict surges to a value harmless to the station insulation.

Great progress has been made in the last few years in knowledge of the behavior of station insulation when subjected to surges. As a result, the maximum surge voltage which station apparatus may be subjected to without injury will no doubt soon be known, but at present this information is far from being complete. It appears certain that for a few years at least, designers must rely on the sum total of experience supplemented by such reliable information on insulation strength of apparatus as becomes available. This does not mean that coordination of insulation cannot be attempted at the present time, but it does mean that with the data available, too much reliance must not be placed on coordination to give results that will always be effective.

### Effect of Lightning Arrester

Fortunately, the same investigations that made possible increased knowledge of insulation strength to surges, also placed the operation of the valve type lightning arrester out of the realm of speculation. It is now possible to state with some definiteness to what value the maximum surge voltage will be limited, with a given arrester. It is, therefore, possible, in the general case, to design the station insulation so that its impulse flashover will be greater than the ceiling voltage of the arrester installed. The term ceiling voltage is defined as the maximum crest voltage at arrester location permitted by the arrester for all types and magnitudes of surges. The impulse strength of bus insulation and to a lesser extent, of high-voltage bushings, is known with some degree of accuracy, but in the absence of such data, a fair approximation can be made on the basis of the 60-cycle insulation strength.

The impulse strength of transformers is still a point regarding which very little is known definitely. Experience with transformers on the lower voltage lines which are protected by lightning arresters, indicates that the arrester having a protective ratio of 3.5 or better will protect the transformer which is designed for standard insulation test against 90 per cent of lightning surges to which it is subjected.[2] It may be concluded that the transformer impulse strength is therefore in the order of at least 2.5 to 3.0 times crest value of system voltage to ground. The coordination of station insulation therefore resolves itself into designing the various parts to have greater strength than the arrester ceiling voltage.

A number of exceptions to the above general condition are evident. In the case of outdoor stations the length of bus may be such that an arrester, if located at the line entrance, may allow surges to pass, of sufficient magnitude to be dangerous to station insulation because of reflections. In these cases, the proper place ror the arrester is adjacent to the transformers, as the reflection is usually highest at this point. Bus insulation can be more readily strengthened to take care of feflection at those points where it may occur.

A condition requiring special treatment occurs in those cases where other than normal number of units are required in the arrester stack to protect the arrester against dynamic overvoltage due to loss of load. The ceiling voltage of the arrester is increased in these cases and the protection given is correspondingly decreased. If the increase in ceiling voltage is appreciable, either the insulation strength of the transformer should be increased, or some of the special features of coordination of line and station insulation attempted. It is felt that the former arrangement is preferable, as the latter is still of too uncertain a nature to be depended upon, especially for stations of large capacity.

A third case is one which applies most particularly to some 220-kv. systems, where advantage was taken of a solidly grounded neutral to specify graded insulation. In these cases, it would be expected that an arrester with the normal protective ratio might not be quite good enough to protect the transformer against all surges. Coordination of line and station insulation may then be used as a last resort, or a spillway or protective gap installed, but drastic reduction in insulation strength on the line adjacent to the station appears to be necessary with its attendant difficulties due to line outages.

Two typical cases are tabulated below for stations of the Hydro-Electric Power Commission. The first, given in Table II, is for a 110-kv. outdoor step-down station, protected by lightning arresters, in which no attempt was made to coordinate line and station insulation, other than by specifying for the station, bus insulation which was known to be satisfactory from previous experience in other stations. It may be stated that no failure of transformer insulation due to lightning has occurred and only two or three flashovers of porcelain in any 110-kv. station of the commission. With one exception, lightning arresters have been installed at such stations and an insulation test of twice maximum rated voltage for the transformers has been specified. None of these transformers have graded insulation.

The second case is that of the 220-kv. line entrance and station bus insulation for Toronto-Leaside transformer station. Two banks of transformers were installed in this station in 1928, and as no satisfactory

TABLE II

110-KV. INSULATION. HAMILTON TRANSFORMER STATION

| Item | Insulation units | Flashover 60 cycle Dry | Wet |
|---|---|---|---|
| Lightning arrester. Oxide film. Total cells 1168. 3 phase stacks and ground stack. Cells per stack—292 | | kv. | r. m. s. |
| Line and bus disconnects.......... | 2 unit pillar | 329 | 220 |
| Circuit breakers—Line............ | 110 kv. bushing | 345 | 300 |
| —Transformer..... | 132 kv. bushing | 400 | 345 |
| —Transformer..... | 110 kv. bushing | 345 | 300 |
| Transformer..................... | 110 kv. bushing | 345 | 300 |
| Strain bus........................ | 10 suspension units 5 inch spacing | 515 | 385 |

ightning arresters were available at that time, a deliberate attempt was made to coordinate the line entrance and station insulation with the transformer insulation. The transformers had the 220-kv. winding insulation graded, and the standard A. I. E. E. induced test of 2.73 times system voltage to ground or 350 kv. was specified. There are four groups of high-voltage coils and as an additional precaution, the line group of coils was provided with insulation equivalent to that for a transformer designed for 440-kv. test voltage.

The various items of the insulation structure are given in Table III

TABLE III

| Item | Insulation units | 60 Cycle flashover Dry | Wet |
|---|---|---|---|
| Line from station to point 2 miles out, with 4 ground wires........ | 14 five-inch, ungraded suspension disks | kv. 665 | r. m. s. 520 |
| Disconnecting switch............. | 6 unit pillar | 645 | 560 |
| Supported bus.................... | 6 unit pillar | 645 | 560 |
| Suspension bus................... | 20-5 inch, ungraded suspension disks | 850 | 670 |
| Oil breaker bushing............... | Oil filled | 585 | 420 |
| Transformer bushing.............. | Condenser—not less than | 550 | 465 |

In spite of this attempt at coordination, an apparatus insulation failure occurred during a severe lightning storm early in 1929. No evidence of lightning flashover on the reduced line insulation was found.

After the failure, a spillway gap was installed adjacent to the transformers having 13 five-inch disks, and arrangements were made to have an equivalent gap tested in the laboratory, both with and without grading rings. Although a number of storms have occurred since installation of the spillway gap, no flashover of the gap has occurred. However, a continuous record was kept during the lightning season with a klydonograph recorder, and no record of any surge of magnitude sufficient to cause flashover of the gap was obtained.

Lightning arresters are now being installed adjacent to these transformer banks, having an estimated ceiling voltage of 870-kv. crest. The relation of this ceiling voltage to the flashover voltage of the spillway gap is shown in Fig. 1.

One other instance of an attempt at insulation coordination is of interest. A number of 110-kv. potential transformers purchased by the commission in 1924, were built to a specification which required that on test, the voltage be applied to the low voltage winding and raised until flashover occurred on the high-voltage bushing.

These transformers have given satisfactory service, but there is no evidence that they would not have given equally as good performance if the above feature had been left out of the specification.

## Summary

The trend of insulation coordination has been indicated and summarized; this trend appears to be somewhat as follows:

1. Knowledge of insulation required for both line and station apparatus has been acquired largely as a matter of experience, and a coordinated system has resulted.
2. Increased line insulation has come about as a result of:
   (a) Recent investigations into behavior of lines and line insulation when subjected to surges.
   (b) Better knowledge of magnitude and character of lightning surges.
   (c) Desire to decrease the number of line outages, especially on important circuits, with relatively high loading.
3. Knowledge of the behavior of station insulation is still such as to allow only very general approximations to be made. The situation is complicated by the very intricate nature of voltage reflections which may occur at points of discontinuity.
4. Station insulation has not been increased because the amount of increase necessary could not be accurately specified, and also because of the difficulty of modifying existing stations to the new insulation design.
5. If the valve type lightning arrester is used, it is a determining factor in station insulation requirements.

## Acknowledgment

The facilities of the High-Voltage Laboratory of the Westinghouse Electric and Manufacturing Company at Trafford were used to obtain the data shown in Fig. 1. It is a pleasure to record the cooperation of engineers of this and other organizations in studies of our insulation problems.

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Abridgment of

# Cathode Energy of the Iron Arc

BY GILBERT E. DOAN*

Non-Member

***Synopsis.**—For purposes of study, the available energy at the cathode of the iron arc for welding in air, and the disbursement of this available energy to the cathode processes, are set up in balance-sheet form.*

*The energy as heat at the cathode includes that from (1) ionic bombardment, (2) ohmic resistance of cathode tip, (3) radiation from the anode, and (4) combustion. Since the division of total arc energy between anode and cathode is nearly an equal one, the sum of the first three should approximate one-half of the total energy input to the arc.*

*Heat Disbursement at Cathode: The principal consumption of heat at the cathode is by (5) melting of cathode, (6) evaporation of atoms at cathode, (7) evaporation of electrons at cathode, (8) dissociation of arc vapors, (9) radiation to anode and to air. Of the total heat disbursed by the arc more than half is consumed, as shown by measurement, by the melting of the electrode. The heat consumption for this melting is greater than the calculated value of total heat received at the cathode. The latter value is therefore incorrect and needs to be revised, using higher values of $V_c$ or $\phi_+$ or both.*

*On the other hand, the calculated total energy consumption at the cathode corresponds closely to one-half the measured total electrical input to the arc and is therefore approximately correct.*

BECAUSE of its growing use commercially, the iron arc in air as used for electric welding has been studied recently by P. Alexander, Weber, Eschholz, Green, and others. Other arcs, such as the mercury arc and the carbon arc, are interesting from the point of view of the classical physicist and present an important field for the study of the electron and atom. In this field, Langmuir, K. T. Compton, Richardson, and J. J. Thomson have contributed to the English literature, while Hagenbach, Seeliger, Schottky, and Günther-Schulze are among the recent contributors to the German literature. Most of the studies of the commercial arc, however, have dealt with the changes of the *materials* of electrode and of the welded article during the progress of the welding, and with the changes in chemical and physical properties of these materials by the welding process. The present paper deals with the changes in *energy* which accompany the operation of the commercial welding arc.

The basis chosen for this study is that of the energy supplied and disbursed at the cathode. The conservation of energy is assumed as a guiding principle. The method followed is one that has yielded fruits in the study of many other processes, physical and physico-chemical; namely, that of quantitative energy analysis. The present study consists primarily casting up the energy balance at the cathode of the arc and of showing the sources of heat, as compared with the measured and calculated disbursements of this heat by the processes involved. The intimate understanding of the arc phenomena thus gained should indicate means for improvement in the welding process.

## Energy Conditions at the Cathode

The cathode conditions have been chosen for first study for several reasons: In the first place, it has recently been recognized that the processes at the cathode are highly important in determining the choice of the electrode or welding wire to be used in commercial welding, and therefore, when the cathode processes are better understood, much of the present confusion in selecting commercial welding wire will, it is hoped, be eliminated. Also, it has been shown[1] that the conditions at the cathode of the arc are considerably less complicated and variable than those at the anode, and are therefore more readily subject to study.

Fig. 1 shows the arc in outline with the polarity used for mild steel. Current flows through the cathode, across the arc-gap, and through the anode plate being welded. The tip of the cathode melts and the cathode globules thus formed fall into the anode puddle, or crater. The freezing of this molten crater in the wake of the advancing arc constitutes the welding process. Some metal deposition in the crater probably also takes place as vapor in addition to the rain of globules. The total electrical energy supplied to the arc is, of course, the product of the total arc voltage and the current flowing. In the commercial arc this quantity is commonly 18 volts times 150 amperes, or 2700 watts or 645 calories per second. Of this total arc energy, that available at the *cathode* tip may be due to:

1. Heat developed at the cathode spot of the arc by ionic bombardment.
2. Heat generated by ohmic resistance in the growing molten cathode globule and in the adjacent electrode wire.
3. Heat radiated to the growing globule from the anode crater.
4. Thermochemical heat of oxidation at and near the surface of the cathode globule in air, and from other minor sources.

The sum of the first three items should equal about one-half of the total arc energy,—645 calories per second,—because the energy division between cathode and anode seems to be practically equal.[2] The discussion and calculation of each of these cathode heat sources will be taken up separately.

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1. For references see Bibliography, complete paper.

On the other hand, the consumption of this energy at the cathode takes place chiefly by:

5. Melting of cathode, including latent heat of fusion and sensible heats of the solid and liquid metal melted.
6. Evaporation of atoms.
7. Evaporation of electrons from the cathode spot.
8. Dissociation of iron vapor and of $N_2$ and $O_2$ gas in the arc stream.
9. Radiation from the cathode crater.
10. Conduction of heat away from the globule through the cathode shank.
11. Gaseous convection and conduction.

These eleven items comprehend the origin and disbursement of the chief energy quantities involved in the cathode process. Since the arc quickly reaches thermal equilibrium, the sum of items 1 to 4 must equal the sum of items 5 to 11, and a thermal balance sheet may be drawn up. This equilibrium is the basis of the present study. The results of a quantitative analysis of these energy relations should be significant in two principal respects; (1) they should show the magnitude of the energy involved in each feature of the cathode processes and thus reveal more clearly their nature; (2) they should test in a rough manner the universality of the conclusions reached by Compton and others in their studies of the mercury arc and carbon arc. With these goals in view, we are ready to consider individually each of the four heat sources mentioned above.

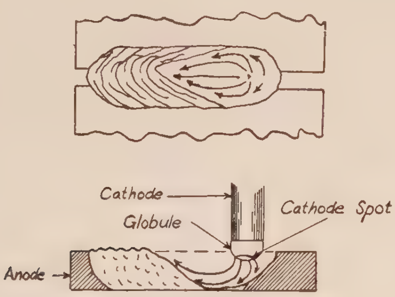


Fig. 1—Welding Arc

### Heat Sources—Part I

*Item 1. Energy Developed at Cathode Spot of the Arc by Ionic Bombardment.* According to Compton,[3] the heating of the cathode accompanying the maintenance of an arc is equal to:

$$(1-f)\,(V_c+\phi_+)+F\,[f\,V_c-(1-f)\,V_i]$$

where $(1-f)$ is the fraction of the current at the cathode which is carried by incoming ions.

$f$ = the fraction of the current carried by electrons evaporated or pulled out from the cathode.

$V_c$ = the cathode fall of potential.

$\phi_+$ = the latent heat of neutralization of positive ions at the surface of the cathode.

$V_i$ = the ionizing potential of the gas in the arc.

$F$ = the fraction of the electron energy which is returned to the cathode by radiation after neutralization of the emitted electron by an ion.

Or, expressed in words, "the heating at the cathode is the sum of the heating due to bombardment of the cathode by incoming ions plus that heat due to the fraction of outgoing electrons which are returned to the cathode." The best values available for each of these times will be chosen. Since both Günther-Schulze[4] and Compton find $f$ between 0.55 and 0.70 as a maximum, considering both the mercury arc and the carbon arc, we shall adopt a mean figure $f = 0.625$ for iron arc. Values of $V_c$ determined by the sounding method have been shown by Langmuir and Mott-Smith[5] to be incorrect and probably several volts too low.

Recent direct measurements[7] of the cathode fall in a mercury arc corroborate this doubt and indicate, surprisingly enough, that the true cathode fall $V_c$ for the mercury arc is higher by several volts than the ionizing potential of mercury ($V_i = 10.4$ volts). By analogy, $V_c$ for iron may also be higher by one or two volts than $V_i$, the ionizing potential of iron, which is given variously as 5.3, 6.5, and 7.83[8] volts. The cathode fall $V_c$ for iron may, therefore, be as high as 9.0 volts. This value would seem to explain more nearly the observed rate of energy liberation in welding, and will be adopted in these calculations. The third factor $\phi_+$ has recently been shown by Compton and Voorhis[6] to be very small—probably zero. Thus:

$$0.375 \times 9.0 = \frac{3.375 \text{ watts} \times 150 \text{ amperes}}{4.18} = 121$$

calories per second.

The second member of the equation, containing $F$, cannot be large. This item is expressed by Compton as $F\,[f\,V_c-(1-f)\,V_i]$ where $f\,V_c$ is the energy gained by the electrons in the cathode fall space; $(1-f)\,V_i$ is the energy of these electrons which is consumed in ionizing the gas whose ionizing potential is $V_i$; and $F$ is the fraction of the remaining energy which is returned to the cathode by radiation, etc. However, since no determination of this factor $F$ has been made, and since it cannot be calculated, it will be necessary to omit this item, (probably a small one), from the calculations until experimental data are available.

Examination of the remaining heat sources, items 2, 3, and 4 at the cathode, will show presently that compared with those just considered, they are relatively small parts of the total energy supplied to the arc electrically.

*Items 3 and 9. The Heat Radiated to and from the Cathode.* The rate of radiation from a globule at temperature 1992 deg. cent. to surrounding air at 20 deg. cent. assuming an emissivity coefficient of unity, is, according to the Stefan-Boltzmann law, 36.4 calories per second per cm.[2] of surface. The intensely hot cathode and anode spots would, of course, radiate much faster, but they are so intimately opposed to each other in the arc that little heat can escape as radiant energy. By considering the area of the cathode spot and the area of the junction of globule to wire separately we can

compute the radiation from the remaining surface of the globule.

The area of a globule 3/16 in. in diameter is 0.715 cm.$^2$ The area of a half globule is of course 0.36 cm.$^2$ The rate of radiation from the cathode spot proper, (itself of area approximately 0.123 cm.$^2$ at 2450 deg. cent. to air at 20 deg. cent.,) would be $55.2 \times 1.41 \times 0.123 = 9.65$ calories per second; but most of this radiation is received by the anode, which it is assumed returns an equal amount to the cathode.

Now, if we subtract from the total area of a full-sized globule the area of the cathode spot 0.1236 cm.$^2$, and also the area of the contact of globule to cathode wire 0.123 cm.$^2$, we have 0.468 cm.$^2$ left. For a half-grown globule, assume the radiating surface to be one-half or 0.234 cm.$^2$; then if the rate of radiation at 1992 deg. cent. is 36.4 calories per second per cm.$^2$, we have $0.234 \times 36.4$ or 8.55 calories per second radiated from a globule of mean area to the air. The total radiation to air and to anode would be 8.55 plus 9.65 or 18.20 calories per second. The total radiation received by the lower hemisphere of the cathode from the anode will be taken as equal to that radiated from cathode to anode, *i. e.*, 9.65 calories. The net loss by radiation from the cathode is thus of the order of 8.55 calories per second, or one per cent of the total arc energy and 3 per cent of the heat disbursed at the cathode. This, again, is rather small as compared with item 1.

*Item 4. Thermochemical Heat.* According to Spraragen, 13 per cent of the weight of cathode melted is lost in welding. The presumption is that it is lost by globule spattering, and as vapor and mist. Iron in this finely divided condition, and at this high temperature, ignites spontaneously[14] in air. It probably forms a burning envelope just outside of the arc proper, and the burning of this envelope will aid in heating the globule by radiating back to the globule some of the thermochemical heat produced in the envelope.

If all of this metal loss to air is considered to be in the form of vapor and mist, then each second 0.0443 grams (see item 6), will burn and generate

$$\frac{0.0443 \times 195{,}600}{112} = 77.3 \text{ calories, according to the}$$

equation: $4\,Fe + 3O_2 = 2\,Fe_2O_3 + 195{,}600$ calories, which thus appears to be one of the largest heat sources in the entire process. All of this heat, however, is not returned to the cathode, because the oxidation takes place not only at the cathode and in the arc stream itself, but also at the anode; most of it, perhaps, in the latter two places. Only a small fraction of this heat is carried to the cathode. If three-fourths of it burns in the arc stream and at the anode, and one-fourth at the cathode, then perhaps one-eighth of this thermochemical heat is absorbed by the cathode globule. It seems very unlikely that more is absorbed. This would give 9.7 calories per second delivered to the cathode from the burning of iron vapor and mist.

This burning envelope which encompasses the entire arc zone is very probably the principal source of the light and heat which the casual observer notices in observing the arc. The actual cathode and anode spots are rather completely hidden from view. The effect of this hot envelope upon the weld is probably to diminish somewhat the very high temperature gradient at the anode, as well as to protect, partially at least, the depositing metal from rapid oxidation.

## Energy Balance at the Cathode

Heat received at the cathode (calories per second) with 150 amperes:

| | |
|---|---|
| (1) By ionic bombardment, etc. | 121.0 |
| (2) By ohmic resistance in the molten globule 1.96 and adjacent 1.24 electrode | 3.20 |
| (3) By radiation from the anode | 9.65 |
| (4) By oxidation of iron vapor and mist | 9.70 |
| | 143.55 |

Heat disbursed at the cathode (calories per second) with 150 amperes flowing:

| | |
|---|---|
| (5) By melting of electrode (including sensible heat) | 161. |
| (6) By evaporation of atoms | 12.6 |
| (7) By evaporation of electrons | 95.5 |
| (8) By dissociation of iron vapor and air | .. |
| (9) By radiation to anode 9.65 and to surrounding air 8.55 | 18.20 |
| (10) By conduction through the electrode shank | 0.00 |
| (11) By gaseous convection and conduction | .. |
| | 287.3 |

## Discussion of Heat Sources

The sources of heat at the cathode just considered indicate broadly, as the balance sheet shows, that we have some 143 calories per sec. available at this point. Of this total, 80 per cent or more is generated in the cathode itself by ionic bombardment and relatively little heat is received from outside sources, such as radiation, burning of iron, or ohmic resistance. This discovery seems to limit any considerable increase in rate of melting to an increase in welding current or in cathode fall.

The calculation of item (1) is of course dependent upon values for $V_c$, $\phi_+$ etc., which are as yet not accurately known even for the mercury and carbon arcs upon which so much study has been expended. It is useful, however, to know the *order* of magnitude of this item for the iron arc and its relative part in the arc process. Refinement of the calculation can be made when more exact data are available.

The heat generated by arc oxidation is a surprisingly large quantity. It is apparently equal to more than 10 per cent of the electrical input to the arc. It deserves careful study. If burned in the theoretical amount of air without losses, this envelope of burning iron would reach a temperature of 1965 deg. cent.

## Heat Disbursement—Part II

*Item 6. Melting and Vaporization of Electrode.* The primary function of the cathode process in welding

is to melt and vaporize electrode material and to deposit this metal in the anode crater. Both the rate of melting electrode and the loss of metal to the air during melting can be measured. These measurements will indicate the speed of welding which can be maintained and are therefore of practical importance.

Under standard conditions as adopted in this study (5/32-in. electrode of mild steel, 150-ampere, 18-volt arc), No. 1 electrode melted at the rate of 0.39 grams per second. The loss to the air during melting was 10.6 per cent of the weight of electrode melted. Another type of electrode melted at the rate of 0.34 gram per second, with a loss of 10.2 per cent. These rates are for hand welding. The G.E. automatic welder gave values which do not differ greatly from these.

The heat required to raise one gram of iron from room temperature to its melting point, to melt it, and to superheat the molten iron to 1992 deg. cent., is 413.4 calories (Richards, "Metallurgical Calculations"). Thus, for 0.39 gram there are needed $0.39 \times 413.4 = 161$ calories per sec., or for electrode No. 2, $34 \times 413.4 = 141$ calories per sec. It is evident at once that the observed rate of melting calls for quite a large amount of heat at the cathode, and also it is apparent that the thermal efficiency of the arc in melting metal is good. It indicates clearly that more energy is present at the cathode than that shown by the calculations in Part I, above. It corroborates the belief that $V_c$ for the iron arc in air is higher than the ionization potential of iron, as Compton has proposed. Since this rate of melting requires more heat than the calculations have shown to be available at the cathode, it is obvious that the calculations must be revised.

A further consumption of cathode energy is required by the vaporization of part of the melted metal. This metal must be heated from 1992 deg. cent. up to the boiling point (2450 deg. cent.) and then vaporized. This action would occur at the hottest part of the globule; namely, the cathode spot itself. The latent heat of vaporization of iron calculated by Trouton's Rule, is 1224 calories per gram. But not the entire 10.6 per cent of it occurs at the cathode. Probably at least half of it occurs at the anode and in the arc stream leaving only

$$\frac{0.106 \times 0.39}{2} = 0.0207 \text{ gram per second from the}$$

cathode. Of this total loss, 0.0207 gram, part is mist and part is spray, neither of which carries the latent heat of evaporation. If this mist and spray constitutes one-half of the total cathode loss then 0.0103 grams per second are actually vaporized, requiring $0.0103 \times 1224 = 12.6$ calories for the true evaporation of atoms at the cathode.

*Item 7. Evaporation of Electrons at the Cathode.* The current at the cathode is carried partly by ions which impinge upon the cathode and partly by electrons which are evaporated from the cathode. The latent heat of evaporation of electrons $\phi_-$ is estimated by Thomas[17] at five volts. Compton[18] believes that this value is too high, and that it should lie between 4 or 4.5 volts. This gives us for the value,

$$f\,\phi_- = 0.625 \times 4.25 \text{ or } 2.66 \text{ volts}$$

$$\text{at 150 amperes } \frac{150 \times 2.66}{4.18} = 95.5 \frac{\text{calories}}{\text{second}}$$

The magnitude of this item, 95.5 calories per sec., indicates again that except for the melting action at anode and cathode, the fundamental processes of the arc and not the attendant ones are most important in accounting for its energy distribution.

*Item 9. Dissociation of Iron Vapor.* The atomic hydrogen arc as developed by the General Electric Company depends for its operation upon the dissociation of molecular hydrogen gas into atomic hydrogen at arc temperatures in the arc stream. Iron vapor is, however, already in the dissociated or non-atomic[19] state and therefore absorbs no heat for this purpose. From the low value of item (1) it seems quite probable that either $N_2$ or $O_2$ is present at the cathode. If so, they would dissociate at these temperatures almost completely into the atomic state.

*Item 10. Conduction of Heat through the Electrode and $I^2$ R Heat Generated in it.* The cooler electrode shank near the globule extracts some heat from the cathode globule by conduction. This raises the temperature of the shank within half a cm. of the globule to a visible red. Experience with continuous welding shows that the rate of advance of the wire by melting is faster than the rate of heat conduction through the wire, and that at a distance of, say, 2 ft. from the tip, no rise in temperature of the wire is perceptible. Therefore, no heat is lost from the cathode by conduction, (if we except that small amount carried away by air convection). The process is simply that the metal of the shank near the arc is preheated by conduction from the globule and a moment later itself re-enters the globule and returns the preheat to it.

While extracting heat from the cathode by conduction from the arc, the electrode shank receives heat uniformly along its length by its ohmic resistance to the flow of current, and delivers this heat as preheated metal to the arc. Near and in the re-crystallization zone the amount of this $R\,I^2$ heat is increased due to rise in temperature of the wire and accompanying rises in specific resistivity and may be considerable in amount. This condition also serves to preheat the shank just before it enters the globule. At room temperature, 0.393 calories per sec. are generated in each cm. along a 5/32 in. wire of mild steel carrying 150 amperes. In the half cm. next to the globule, the mean temperature is near 765 deg. cent. $\left(\frac{1530 - 0}{2}\right)$; the mean specific resistivity is much greater (about 9 times), and as much as 1.24 calories per sec. may be generated in this section.

This heat is a substantial contribution to the heat sources at the cathode; and since this voltage drop occurs outside the arc, and addition must be made for this amount. Added to the $I^2 R$ heat from the globule proper, we have $1.96 + 1.24 = 3.20$ calories per sec. heat added to the globule from these sources.

*Item 11. Heat Loss by Gaseous Convection and Conduction.* The loss of heat by gaseous convection and conduction from an arc maintained in still air is very small (Langmuir, *General Elec. Rev.*, March 1926) unless the arc be cooled by blowing it. The loss from the cathode may be negative and would be so if the surrounding gas were hotter than the cathode itself, which probably is the case in the iron arc. For these reasons, this small item will be neglected in the present calculations.

### Discussion of the Balance Sheet

The outstanding result of the attempt to balance the energy account at the cathode is the appearance of a deficit of energy of about 144 calories. This makes the cathode account show only 45 per cent of the energy which must be present there during welding, as demanded by the measured rate of melting, etc. In attempting to find the source of error item 1 offers the best possibilities. Either $V_c$ or $\phi_+$ may be larger or $f$ may be smaller than is now supposed. It is hoped that more of these data will become available.

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Abridgment of

# Effect of Armature Resistance Upon Hunting of Synchronous Machines

BY C. F. WAGNER*

Member, A. I. E. E.

***Synopsis.***—*The ability of systems to withstand shocks, such as faults or switching operations, is much greater for small operating angles. The present paper has to do with system stability for small oscillations as contrasted with the more usual concept of stability as being its ability to withstand shocks.*

*The analysis shows that synchronous machines without amortisseur windings and with no resistance in the armature are inherently stable for small oscillations in prime mover input or load output. With resistance in the armature, stability for such conditions is dependent upon load.*

*A new proof is given for the relation previously derived by Nickle and Pierce which states that the limiting angle at which a machine becomes stable is* $\tan^{-1}\dfrac{r}{x_q}$.

*Arguments are presented which show that any standard type of damper which may have been installed in generators for other incidental reasons possesses the property of preventing spontaneous hunting except for the most abnormal conditions met in practise.*

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DUE to the recent emphasis placed upon system stability and the analysis of system stability by means of the power circle and power-angle diagrams, stability in general has come to be associated with the power-angle diagram. The power-angle diagram gives a measure of the synchronizing power between two machines. From these conceptions, the idea has been developed that a system is better able to withstand disturbances when operating at small angles. It therefore comes as somewhat of a surprise to learn that under certain conditions, a system is more stable at larger operating angles than at small angles. It is with this phase of the stability problem that the present paper is concerned. The phenomena analyzed should not be confused with the ordinary conception that a system is better prepared to withstand shocks when operating at small angles.

From time to time, cases of spontaneous hunting arise, the cause of which can be traced to an excessive proportion of resistance in the armature circuit; namely, in the transmission line. This phenomenon was particularly evident in the early days of rotary converters. A rough working rule in use at that time was to limit the line resistance to 25 per cent of the reactance. In 1911 Dreyfus,[1] in Germany, showed that the tendency toward hunting decreased with increasing load, and that the presence of damper windings tended to stabilize the conditions. In 1924, reporting stability tests made in the works of the Westinghouse Company, Evans and Bergvall[2] demonstrated this same effect, using salient-pole generators and condensers. More recently, Wennerberg[3], in Sweden, and Nickle and Pierce[4], in this country, have extended the analysis, developing the results into more usable form. The author has been working on this same problem and has used a somewhat different method of attack which he believes gives a somewhat clearer conception of the mechanism involved.

## I. Qualitative Analysis

To get a picture of what occurs when a machine becomes unstable and begins to hunt because of the presence of an excessive amount of resistance in its

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1. For reference see Bibliography.

*Presented at the North Eastern District Meeting of the A. I. E. E., Springfield, Mass., May 7-10, 1930. Complete copy upon request.*

armature circuit, consider a synchronous generator without damper windings and having constant exciter voltage, connected to an infinite bus through a transmission line. The analysis of transients of synchronous machines may be expedited by the use of the so-called "transient reactance" ($x_d'$), and the "transient internal voltage" ($e_d'$). The transient reactance is the reactance to be used in connection with the determination of current flow for sudden changes. It includes not only the armature leakage reactance but also the effects due to the field leakage. The subscript $d$ signifies that the reactions are taken with reference to the direct axis. The voltage $e_d'$ for zero power factor will be defined as the arithmetic sum of the terminal voltage and the transient reactance drop, and for any other power factor, as the arithmetic sum of the component of the terminal voltage in the direct axis and the transient reactance drop due to the component of armature current in the direct axis. This is the fictitious voltage corresponding to flux linkages in the field and for any sudden change in circuit condition the flux linkages and this voltage remain fixed. The voltage $e_d$ will be defined in a similar manner except that the synchronous reactance $x_d$ must be used. It follows, therefore, that $e_d$ and $e_d'$ for steady state conditions differ only by the magnitude of the two drops and that

$$e_d - e_d' = x_d\, i_d - x_d'\, i_d$$

or

$$e_d' = e_d - (x_d - x_d')\, i_d \qquad (1)$$

in which $i_d$ is the component of armature current in the direct axis; that is, it is the demagnetizing component of current for $i_d$ positive. The quantity $(x_d - x_d')$ takes something of the nature of a reactance corresponding to armature reaction. It is clear, then, from the above equation and also from the physical conception of the quantities, that for constant exciter voltage, which is equivalent to constant $e_d$, that the voltage $e_d'$ which is proportional to flux linkages in the field winding should decrease as the demagnetizing component of current, $i_d$, increases.

In Fig. 1a is shown the familiar power circle diagram, showing the output characteristics of the machine for constant internal voltage assuming no resistance in the armature. This diagram is not strictly correct, as it does not introduce the distortion due to the saliency of the poles. It is, however, sufficiently correct for this preliminary analysis. For any operating point such as $p$, the abscissa gives the power output of the machine and the ordinate, the demagnetizing kv-a. The angle $\theta$ is the angle between the generated voltage and the voltage of the infinite bus at the receiving end. The particular circle drawn assumed constant voltage $e_d$, so that the circle represents the steady state characteristics.

Now, assume that the generator is operating at a mean angle $\theta$ and that in some manner, (the exact nature of which is at present of no importance), the rotor is made to oscillate sinusoidally about $\theta$ with an amplitude $\Delta\,\theta_m$ and a frequency $f$. The amplitude of these oscillations is indicated in Fig. 1a, from which it will be observed that for $\Delta\,\theta$ positive the demagnetizing kv-a., or the demagnetizing current $i_d$, increases. But from Equation (1) it was shown that if $i_d$ increases, $e_d'$ decreases. It follows therefore that for positive increments in $\theta$, the increment of $e_d'$ is negative, and for negative increments of $\theta$, the increment of $e_d'$ is positive. This result is shown graphically by the straight line in Fig. 1b. However, this relation merely shows how $\Delta\, e_d'$ would vary if $\theta$ were increased an amount $\Delta\,\theta$ and kept there or the manner in which $\Delta\, e_d'$ would vary for very slow oscillations. Due to the inductance associated with the field circuit, $e_d'$ cannot change instantly, so that the variations of $\Delta\, e_d'$, instead of oscillating along the straight line, will form an elliptical loop (Lissajous figure) of the form shown. The direction of rotation of the generating point around this loop is extremely important. It will be observed that if $\Delta\,\theta$ be increasing positively from its value $-\,\Delta\,\theta_m$, the

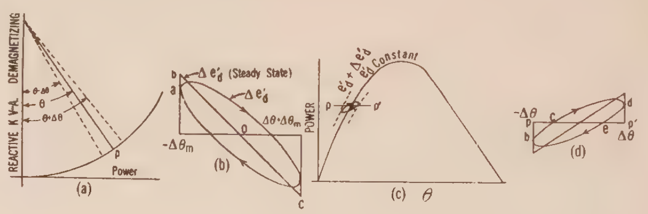


FIG. 1—PURE REACTANCE LINE

a. Demagnetizing current increases with $+\,\Delta\,\theta$, so that $\Delta\, e_d'$ tends to decrease
b. Log of instantaneous value of $\Delta\, e_d'$ behind value which it would attain for steady state conditions
c. Power loop obtained from instantaneous values of $\Delta\, e_d'$. System stable for clockwise loops
d. Enlargement of power loop

operating point $a$ in generating the loop must lag, that is, it must pass through zero at a later time than when $\Delta\,\theta$ passes through zero. This determines the direction of rotation as being clockwise. With very low frequency, the loop degenerates into the straight line $b\,c$ and for extremely high frequencies degenerates into a straight line along the horizontal axis.

The power-angle diagram for the machine including the effect of salience is shown in Fig. 1c. This curve was drawn for a constant value of $e_d'$. For small positive increments in $e_d'$, the resultant curve will in general for almost all cases met in practise, lie above the one for $e_d'$; and for negative increments of $e_d'$, will lie below the curve for $e_d'$. The loop of Fig. 1b gives the instantaneous values of $\Delta\, e_d'$ as a function of the angle so that using these instantaneous values, it can be seen that a similar power loop is obtained on the power angle diagram and following the point-by-point substitution, it will be observed that the rotation of this movement is also clockwise. Assuming constant input into the prime mover of the value corresponding to the generator power output for the mean value of $\theta$, the instantaneous

acceleration is determined by the distance between the curves of instantaneous power and the line $p\,p'$. Starting at the point $b$ of maximum negative travel (see Fig. 1d) where the relative velocity between the rotor of the machine and the voltage of the infinite bus is zero, the velocity of oscillation under the assumed conditions of constant input increases until the point $c$ is reached, at which point the acceleration is zero. At this point the rotor has accumulated an amount of stored kinetic energy proportional to the area of the triangle $b\,p\,c$, so that the rotor overshoots this point. The relative velocity is again brought to zero at the point $d$ but it will be observed that the area representing the energy available to retard this velocity—area $d\,p'\,c$—is greater than the area $b\,p\,c$. The significance of this observation is that, left free to oscillate from point $b$ with constant prime mover input, the generating point will not move all the way to $p'$, but will be damped; or, if the generating point does actually move along the locus $b\,c\,d$, then the assumption of constant prime mover is incompatible with the results, the prime mover input represented by the line $p\,p'$ must be altered so that the two areas are equal. In moving from $b$ to $d$, the excess energy tending to produce damping is proportional to the difference of the areas $d\,p'\,c$

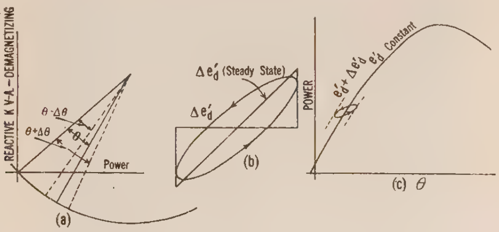


FIG. 2—LINE WITH RESISTANCE

a. Demagnetizing current decreases with $+\Delta\theta$, so that $\Delta e_d'$ tends to increase

b. Log of instantaneous value of $\Delta e_d'$ behind value which it would attain for steady state conditions

c. Power loop obtained from instantaneous value of $\Delta e_d'$. System unstable for counter-clockwise loop

and $b\,p\,c$; but since area $b\,p\,c$ is equal to area $d\,p'\,e$, this difference is equal to the area $c\,d\,e$. Similarly in moving from $d$ to $b$, the excess energy tending to produce damping is proportional to the area $e\,b\,c$, or during one complete cycle, to the area of the loop.

The system may be said to be stable. It will be observed that this condition holds for all values of $\theta$ when the armature resistance is zero.

An entirely different condition may prevail when the armature and line resistance is other than zero. Consider the conditions when such a system is operating at the angle $\theta$ shown in Fig. 2a on the power-reactive power circle diagram; due to the presence of the resistance, the center of the circle is shifted from the axis of reactive kv-a. to the position shown. For positive increments in $\theta$, the demagnetizing current decreases, thus increasing the value $\Delta e_d'$ attains for steady state increments of $\Delta\theta$. This relation is shown in Fig. 2b. During system oscillations $\Delta e_d'$ cannot attain the value corresponding to the steady state value, but lags forming the loop shown, which is generated in a counter-clockwise sense. The voltage loop can be converted to the power loop in Fig. 2c, which is also generated in a counter-clockwise sense. Pursuing the same argument as used previously, the area of this loop is proportional to the energy given out,—the system is unstable.

This condition follows from the fact that for small angles, the demagnetizing current decreases with increasing angle; but it will be noted that for larger angles, this same relation no longer obtains. As the load increases, a point is finally reached beyond which the system becomes stable. The qualitative treatment thus shows the mechanism of the phenomena involved and why, from the standpoint of hunting, a machine without damper windings becomes more stable with increasing load.

This phenomenon should not be confused with energy absorbed thermally by the series resistance, which is not effective in damping oscillations between machines. The truth of this statement may be verified by assuming that the oscillations are so fast or that the time constant of the field is so large as to justify the assumption that $e_d'$ is constant. Any effect of the series resistance should still be present. In this case, the operating point in the power-angle diagram generates the same locus with increasing angles as with decreasing angles. The area of the loop and the decrement of the oscillations must therefore be zero. For constant prime mover input and constant load output, the energy absorbed by the series resistance is supplied by the stored kinetic energy of rotation, resulting in a decrease of mean system frequency.

## CONCLUSIONS

Theoretically, an ideal machine without amortisseurs, when operating at light loads, should hunt. The lack of such hunting in modern transmission systems is explained by the presence of current paths in the quadrature axis afforded by rivets and parts of the field structure. Except for very abnormal conditions, any normal design of amortisseur that is installed for other purposes will be found adequate incidentally to prevent spontaneous hunting.

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Two new steam turbo generators, each of 160,000-kw. capacity, will be installed in the Hudson Avenue station of the Brooklyn Edison Company during the next two years, according to Matthew S. Sloan, president of the New York Edison and affiliated electric companies. Bids have been asked for these units, which will raise the capacity of the Brooklyn station to 770,000 kw.

When these generators are in service, the Hudson Avenue station will have a total capacity larger than the present capacity of 810,000 hp. at Hell Gate, which is now the largest steam plant in the world.

# Development of a Two-Wire Supervisory Control System

## with Remote Metering

BY R. J. WENSLEY* and W. M. DONOVAN*

Associate. A. I. E. E. Non-member

*Synopsis.—This paper describes the conditions leading up to the development of the two-wire supervisory control system. It enumerates the outstanding requirements of supervisory control systems in general and indicates a number of the advantages of the two-wire system. It provides a brief description of the operation of the system.*

THE first installation of supervisory control equipment on a commercial basis was made on the system of the Cleveland Railways Company approximately nine years ago. This installation is still operating in a highly satisfactory manner and has been added to from time to time, so that it still ranks among the larger installations of this nature.

From this beginning, there has come into existence a number of different forms and types of apparatus which may be included under the general classification of supervisory control equipment. An intimate association with the development of a large number of these systems has made possible a thorough study of the requirements as outlined by operating companies throughout this and other countries.

In the search for a suitable type of apparatus which would be both compact and reliable, recourse was had to the products of the telephone manufacturing companies engaged in the design and construction of automatic telephone exchanges and similiar equipment. Here it was found possible to obtain relays having satisfactory characteristics which were compact and at the same time of sturdy construction. There were also available various types of selector switches which were equipped with step-by-step mechanisms which could be used for transmitting and receiving trains of impulses.

Shortly after the first installation of supervisory control equipment for the Cleveland Railways Company, it was decided that an investigation should be undertaken to determine the possibility of simplification and reduction in space requirements. The suitability of a system of supervisory control which would operate through the medium of telegraphic signal codes transmitted from one station to the other was also considered. Codes of a similar nature are widely used in the automatic telephone industry.

It should be noted that the situation in connection with the remote control of power equipment is somewhat different from that encountered in the selection of the proper number in a telephone exchange. Being connected to the wrong party is disagreeable for all of us; but it is quite evident that this condition is not nearly so serious in connection with communications as would be the case if we were to operate the wrong circuit breaker in a power station. Obviously, there must be some means of insuring the reception of the correct signal at the remote station.

To meet these requirements, there was developed the code visual type of equipment, which was originally known as the "switch" type to differentiate it from the "all-relay" type previously developed.

The code visual supervisory control equipment was designed and manufactured with the rotary type selector switch as a nucleus. Inasmuch as the particular type of switch selected for use was equipped with 25 steps, or contacts, a series of impulses totaling 25 was considered to be the most suitable for the application.

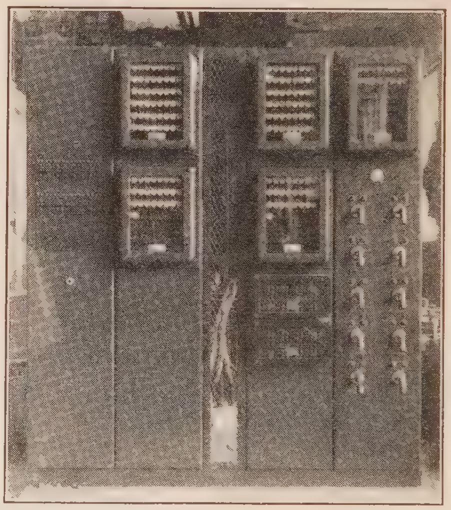

Fig. 1—View of Control Panels

The equipment was so designed that this series of impulses consisted of 22 short impulses or dots, and three long impulses or dashes. The first two long impulses might be included in the series at any point, but the last long impulse must always be the 25th in a correct series of impulses. Thus, if the 25th impulse of any series were not a long impulse, the final circuit could not be completed to cause an operation.

The code visual type supervisory control equipment in its commercial form required three wires between the dispatching office and the substation. These consisted of a common wire, a control wire and a supervision wire. By means of circuits well known to the telegraphic art,

*Both of Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

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the code visual equipment could be operated over two line wires between the dispatching office and the substation; but such an arrangement was not considered commercially feasible because it required frequent attention and delicate adjustment.

In order to provide the most reliable check upon the correctness of the signal received, it was determined that the most satisfactory system would be one making use entirely of relays.

Considerable interest was also expressed in the possibility of reducing the line wire requirements from three wires to two wires, particularly by those operating companies who lease their communication circuits from the local telephone company. Inasmuch as the communication circuits are leased on the basis of so many dollars per circuit mile, it is evident that a system requiring three wires will represent twice the expense in line wires that a system requiring two wires will, since it is necessary to lease four wires, even though only three are required.

It may be of interest to indulge in a little simple arithmetic to illustrate the financial advantage of a supervisory control system requiring only two wires over a similar system requiring three or four wires. The average cost per circuit mile for leased wire circuits obtained from the telephone companies in various parts of the country is approximately $42.00 per year. Assuming a nominal distance of five miles between the substations, the yearly cost for a single circuit would be $210.00. Now considering a 12 per cent return upon the capital investment to be a fair average, the expense for a two-wire line will represent a capital investment of $1750.00. Obviously, if three wires are required, it will be necessary to lease two circuits, thus doubling the expense and representing a capital investment of $3500.00. From this it is evident assuming the two systems are equivalent in other respects that the operating company can well afford to expend something more for a supervisory control equipment which requires only a single circuit rather than two circuits between the dispatching office and the substation.

There are a number of other requirements which have been found desirable by various operating companies during the course of development of supervisory control. These have been given careful consideration in the design of the two-wire system.

An ideal system of supervisory control should have the following characteristics:

1. The equipment must be simple in construction and operation.
2. It should occupy the minimum amount of space consistent with satisfactory operation.
3. It must be flexible in design so that the control key units may be mounted upon a desk or a panel. The units may be arranged in groups or as a part of a miniature bus layout.
4. It must present a neat appearance and be suitable for installation in line with the usual form of power station switchboard.
5. It should require the minimum number of line wires between the dispatching office and substation consistent with reliable operation.
6. It should require a minimum amount of attention and maintenance at regular intervals.
7. It should be protected from damage due to excessive voltages on the supervisory control lines between stations.
8. It should not be possible to obtain any false operation of apparatus units due to unusual conditions in the supervisory control equipment itself, or upon the control wires between stations.
9. It should be possible to obtain selective remote metering indications without requiring extra wires.

A study of the general trend of the specified requirements will indicate that the latest development in the field which is known as the "visicode" system approaches most nearly the ideal supervisory control system.

This design, operating over two line wires, utilizes the same type of telephone relays which has been used since the entrance of supervisory control systems into the commercial field. These same relays have been used in automatic telephone exchanges for approximately a quarter of a century. The relays are all of standard construction and are given a definite factory adjustment which requires no change under service conditions, inasmuch as they are given a thorough test and inspection at the factory before shipment.


Fig. 2—Arrangement of Control Board

The visicode supervisory control equipment consists essentially of a dispatching office unit, with its associated control escutcheons, and a substation unit, with its associated interposing relays and signaling equipment. The dispatching office unit and the substation unit are similar in construction and in design of the fundamental circuits. Each unit is composed of transmitting relays, receiving relays, and line transfer relays, together with the required in-

dividual point relays, according to the size of equipment.

The transmitting relays are composed of a relay chain which actually provides the means of sending out the impulses, and a series of selection relays to determine what particular portion of the code is to be transmitted by the relay chain. The receiving relays may be divided into the group receiving relays, the unit receiving relays and the operation control receiving relays. The line transfer relays consist of those relays which provide for the transfer of the line connections from the transmitting relays to the receiving relays, and vice versa, at the proper time in the operation of the equipment.

In controlling an apparatus unit at the distant station, the first operation at the dispatching office is the energizing of an individual point relay by depressing the control key at the bottom of the proper escutcheon. This in turn causes the operation of the local line transfer relays in such a manner as to interrupt the line circuit, thus releasing the apparatus at the local station and at the remote station from the normal position of rest.

At the local station, the interruption of the line circuit causes the equipment to be prepared for the transmission of the first series of impulses. These impulses cannot be transmitted, however, until the line circuit has been completed at the remote station. At the remote station, the interruption of the line circuit causes the equipment to operate in such a manner as to connect the first set of receiving relays to the line circuit in preparation for receiving the first series of impulses.

After the transmission of this series of impulses, the line transfer relays at the local point disconnect the transmitting relays and connects the first set of receiving relays at this station. Simultaneously, the line transfer relays at the remote station operate in such a manner as to disconnect the first set of receiving relays from the line between stations and connect the transmitting relays in such a manner as to transmit the first series of impulses from this station as soon as the receiving circuit has been set up at the local station.

At the conclusion of the first series of checking impulses, the line transfer relays at the remote station operate in such a manner as to disconnect the transmitting relays and to connect the second series of receiving relays. At the same time, the line transfer relays at the local station act in such a manner as to disconnect the first series of receiving relays and to connect the transmitting relays preparatory to transmitting the second series of impulses from this station. This series of impulses is sent out as soon as the receiving circuit at the remote station is prepared to receive it.

The completion of the second series of impulses transmitted from the local station causes the line transfer relays to operate, disconnecting the transmitting relays and connecting to the line circuit the second set of receiving relays. The line transfer relays at the remote station also operate to disconnect the second set of receiving relays and to connect the transmitting relays preparatory to sending out the second series of impulses from this station.

Upon the completion of the series of checking impulses from the remote station, the line transfer relays at that station disconnect the transmitting relays and connect the operation control receiving relays to the line. At the local station, the line transfer relays disconnect the second set of receiving relays from the line and connect the transmitting relays to the line preparatory to sending out the operation control impulses.

At the local station, the completion of the third series of impulses permits the line transfer relays to disconnect the transmitting relays and connect the third set of receiving relays which correspond to the operation control receiving relays at the distant station.

The line transfer relays at the remote station disconnect the operation control receiving relays from the line, at the same time causing the operation of the apparatus unit and connecting the transmitting relays to the line preparatory to transmitting the third series of im-

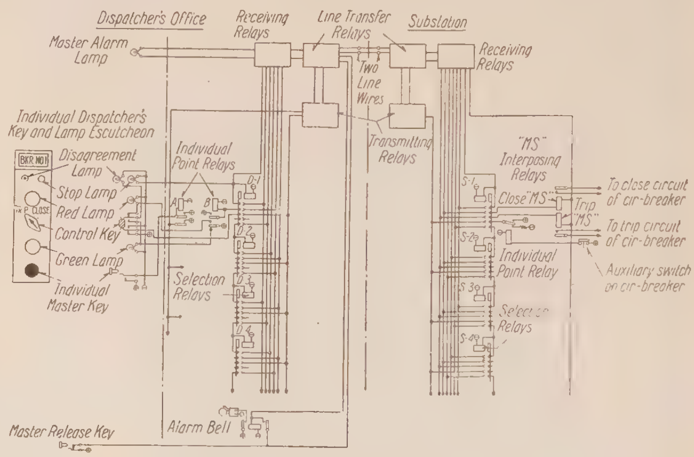


FIG. 3—SCHEMATIC DIAGRAM OF FUNDAMENTAL PRINCIPLES OF OPERATION

pulses as soon as the apparatus unit has changed position.

When the third series of impulses or indication code has been transmitted from the remote station to the local station, thus indicating that the apparatus unit has actually changed position, the line transfer relays at both stations are actuated in such a manner as to disconnect both transmitting and receiving relays from the line and restore the equipment at each station to its normal condition.

In case the operations were originated at the remote station, the functioning of the equipment would be the same as that described above, except that in this case, the remote station would be the first to transmit a series of impulses. Furthermore, at the conclusion of the third series of impulses transmitted from the remote station to the local station, the equipment at the remote station would be prepared to receive the third series of impulses from the local station and the local station would be prepared to transmit the third series of impulses, only when the proper circuit is set up by the operator at the local station.

After this circuit is completed by the operator at the local station, the third series of impulses is transmitted from the local station to the remote station if desired, thus causing the operation to take place, after which the third series of impulses is again transmitted from the remote station to the local station, thus indicating the change of position of the apparatus unit.

In case the operator at the local station did not desire to cause an operation of the apparatus unit at the remote station, the equipment at both stations could be restored to normal by depressing the release key. This same release key may be used at any time during the cycle in order to cancel an operation which has been started but is not to be completed. Release is instantaneous with the pressing of the key.

Practically any operation can be performed by means of the visicode supervisory control equipment which does not require the simultaneous use of more than two wires between the local station and the remote station. We may close and trip a circuit breaker or similar switching device, raise and lower the voltage of a generator by means of a motor-operated field rheostat, control the operation of a voltage regulator, control the gate opening on a waterwheel generator, and many other similar functions. We may also give the indications associated with these various control operations, and in addition, we may indicate water level and approximate load upon a machine by means of step-by-step indication.

Current-balance remote metering may be used in conjunction with the visicode supervisory control equipment, operating over the same pair of wires between the local station and the remote station. It is evident that the metering indications will necessarily be obtained selectively and that the operation of an apparatus unit cannot be obtained at the same time as a metering indication. However, an automatic operation which may have occurred during this time will be indicated immediately upon the release of the metering circuit. Furthermore, a change in position will be indicated even though the apparatus unit may have returned to the original position.

By means of current balance remote metering equipment, we may obtain accurate indications of current, voltage, kilowatts, and any other type of indication which may be obtained by the use of a Kelvin type of instrument.

In order to obtain a selective remote metering indication, we assign a standard point for this purpose so that whenever this particular point is selected, the line wires are connected to the remote metering circuit and are disconnected from the transmitting and receiving relays at each station. In order to release the remote metering circuit so that other operations may be performed, the operator at the local station depresses the release key, thus opening the line circuit and causing the supervisory control equipment at both stations to be restored to the normal condition.

# Recording Fast Transient Phenomena

## With Cathode Ray Oscillograph in Free Air as Well as in High Vacuum

BY M. KNOLL*

Non-Member

**Synopsis.**—*In spite of the great improvements which the cathode-ray oscillograph for high-vacuum photography has undergone in the last few years, the problem of photography in free air is most important on account of the great simplifications for general construction and for taking of photographs. An available method for taking photographs outside the vacuum was found to be the employment of an electron permeable window (Lenard window) of the size of the oscillogram to be made. Ordinary aluminum or cellon foil of approximately 7 or 16 μ thickness respectively may be used if the common exciting voltages of 65-75 kv. are employed. With such foils, all results are to obtain which hitherto have been feasible only with high-vacuum photography. According to this method, oscillograms in free air were taken which attained recording speeds up to 5000 km. per sec., using an exciting voltage of 75 kv. only. With this recording speed, details in the oscillograms of the duration of one milliardth of a second may be dissolved. As compared with the high-vacuum photography hitherto exclusively used for recording quickest phenomena, the Lenard window oscillograph allows taking photographs in a considerably shorter time with the advantages of the simpler construction and manipulation.*

### General Improvements in High-Vacuum Photography

To record fast transient phenomena with the cathode-ray oscillograph, hitherto, the photographic layer had to be brought into the high-vacuum, which caused many troubles and inconveniences in manipulating such apparatus.

Certainly the difficult method of photographing in high vacuum has been very much improved by the development of the cathode ray oscillograph in late years. In the Hochspannungslaboratorium of the Technische Hochschule, Berlin,[1] for example, transportable oscillographs for vacuum photography have been built, allowing the exposure of film strips up to 240 m. and more in length without interrupting the vacuum. Such an oscillograph was working for many hours every day on a lightning observatory on Monte

*Hochspannungslaboratorium of the Technische Hochschule, Berlin.

1. Director, Prof. A. Matthias.

Generoso, in Switzerland, during the whole summer of 1929, without having a single disturbance of vacuum. During a very long thunderstorm, it was possible to record automatically more than 1000 oscillograms on one single film. Later, the same laboratory built a cathode ray oscillograph allowing, by means of a mercury barometer device, film strips of any length to draw continuously from free air through the high-vacuum. In this case also the relatively short interruption of working caused by loading new film into the high vacuum is avoided; a cathode ray oscillograph of this construction is really ready every moment to record any desired number of oscillograms successively.

In spite of the above mentioned and other advantages,[2] the observation of the few methods which enable photography of quick phenomena outside the vacuum is of greatest importance for in this way size, weight, and costs of manufacturing of cathode ray oscillograph can be considerably decreased and the whole method of taking photographs can be largely simplified.

### Photography in Free Air Through Lenard Window

The only method that hitherto allowed the taking of oscillograms equivalent to high-vacuum photographs in the whole range of recording speeds is the employment of a thin electron window (Lenard window). In this case the cathode-ray impinges in free air directly from high vacuum on the whole recording area to the photographic layer. The electron window is thereby supported against the air pressure by means of a grid which must be constructed to produce as little shadow as possible. First it will seem that a very high exciting voltage of the cathode ray tube would be necessary in order that the electrons retain sufficient energy to blacken the photographic layer after having passed through the Lenard window. Since, however, the electrons coming out from the window have practically the same velocity as before, and only their number is decreased, conditions in reality are more favorable.

*Foil.* Experiments had shown that the usual sorts of aluminum or cellon foils can be used also for the large area needed for the recording of oscillograms. The manipulation of such foils on the cathode ray oscillograph is not difficult, since the foil is not heated at all and the oscillograph for other reasons is still connected with the vacuum pump so that small holes in the foil are of no importance. Aluminum foils down to 7 $\mu$ and cellon foils down to 16 $\mu$ thickness also proved sufficiently safe for long working periods and a considerable number of photographs. Calculation shows that if the exciting voltage of 65-75 kv. required otherwise in photographing high-speed phenomena is applied, from 50 to 60 per cent of all electrons pass through such thin foils with nearly undiminished velocity. This would mean that in using the Lenard window method, practically the same height of recording speeds can be reached as with high-vacuum photography.

2. The improvements which have been attained in the construction of cathode ray oscillographs during the last two years in the Hochspannungslaboratorium of the Technische Hochschule, Berlin, will soon be described in a "Forschungsheft der Studiengesellschaft für Höchstspannungsanlagen, Berlin."

*Result of Experiments.* The first photographs in free air with Lenard window were made some time ago[3] in the Hochspannungslaboratorium of the Technische Hochschule, Berlin. They have confirmed what has been said above and have proved that no indistinctness of the oscillogram is caused by the scattering of electrons in the foil. Slack[4], some time afterwards, when describing a Lenard tube with glass window, pointed out the possibility of using such a tube as a cathode ray oscillograph. He worked without a supporting grid, and to bear the atmospheric pressure, his electron window had the shape of a hollow hemisphere. The photographic layers would have to be adapted to this form so that in this case working with usual plates or films is not possible.

Our further experiments referred to the construction of metal discharge tubes of cold cathode type suitable

Fig. 1—Lenard Window, 4 Cm. x 6 Cm., for Cathode Ray Oscillograph

for continuous work up to 90 kv. and more.[5] These tubes increased considerably the efficiency of the cathode ray oscillograph for high-vacuum photography. After reaching satisfactory results, trials were continued with a new supporting grid,[6] and thereby it was found that an exciting voltage of 75 kv. is already absolutely sufficient to record in free air even the quickest phenomena.

*Oscillograms.* Figs. 2 to 5 show illustrations of oscillograms photographed in free air through cellon foil of 4- by 6-cm. surface and 16 $\mu$ thickness, which was

3. M. Knoll, *Zeitschrift für Technische Physik* **10**, 28-30, 1929, No. 1.

4. *Journal Opt. Soc. Amer.* and *R. S. I.* **18**, 123-126, 1929, No. 2.

5. The development and experimental improvement of these tubes was carried out chiefly by H. Knoblauch, Berlin; see M. Knoll, H. Knoblauch, and B. v. Borries, *Elektrotechnische Zeitschrift* **51**, 1930.

6. The development and considerable improvements of the shadowless supporting grid was carried out by B. v. Borries, Berlin. For details see M. Knoll and B. v. Borries, *Zeitschrift für Technische Physik* **11**, 111-112, 1930, No. 4, and *Elektrotechnische Zeitschrift loc. cit.*

supported by a grid of steel ribbons with a close-knit wire gauze of phosphor-bronze stretched over it (see Fig. 1). The free meshes of the wire gauze were small as compared with the breadth of the lines of the oscillogram; they each amounted to 0.003 mm.[2] The exciting voltage was 75 kv.; the current remained within the usual limit of one milliampere.

As will be seen, the oscillograms show practically the

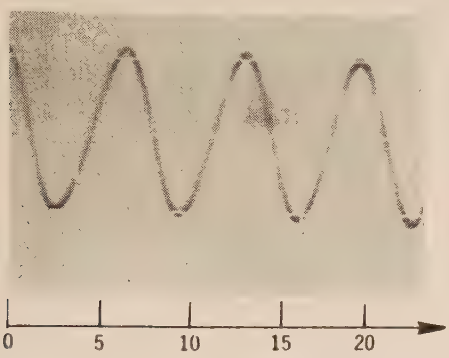


Fig. 2—Free-Air Oscillogram through Lenard Window; High-Frequency Oscillation: λ = 2000 m; Max. Recording Speed 10 Km/Sec.; Abscissa in Millionths of a Sec.

same distinctness of line as high-vacuum photographs. Owing to scattering of electrons the wire gauze remains imperceptible to the eye, and only the steel skeleton serving as coordinate system, can be seen as a faint shadow. Fig. 5 is not only the quickest oscillogram that has been taken up to this time with cathode ray

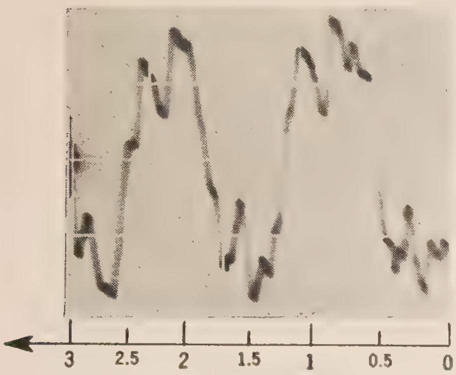


Fig. 3—Free-Air Oscillogram through Lenard Window; Short Circuit of 100-m. Line; Max. Recording Speed 230 Km/Sec; Abscissa in Millionths of a Sec.

oscillograph in free air, but also as far as we know the oscillogram with the greatest recording speed hitherto communicated at all. The maximal recording speed is 5000 km. per sec. in this case. This easily allows dissolving phenomena of the duration of one milliardth of a second and exceeds the achievements so far known of the best cathode ray oscillographs with high-vacuum photography.

## Conclusions

The greatest advantage, however, of the new method lies in the simple and fast manner of working; therefore we believe that high-vacuum photography, (which, compared with photography in free air, is inconvenient and difficult), wil lnot be needed in future. Of course, the fixing of any desired film length for automatic

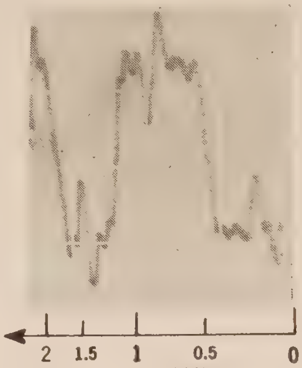


Fig. 4—Free-Air Oscillogram through Lenard Window (Bromide-Paper); Short Circuit of 100 m. Line; Max. Recording Speed 260 Km/Sec.; Abscissa in Millionths of a Sec.

recording is especially easy when using the Lenard window method; besides this, our experiments have shown that for free-air photography the ordinary bromide-paper otherwise used in electrodynamic oscillographs is suitable. The use of this recording paper,

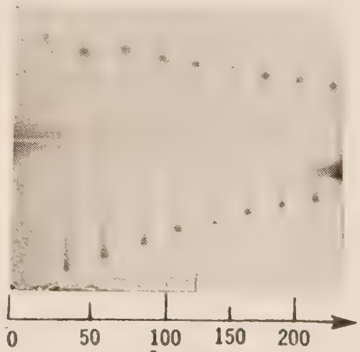


Fig. 5—Free-Air Oscillogram through Lenard Window; Short Circuit of 1.2 m. Air-Insulated Conducting Wire Laid in Metal Tube; Max. Rec. Speed 5000 Km/Sec; Abscissa in Milliardths of a Second

of which Fig. 4 illustrates an original photograph, has great advantages in many cases in comparison with film strips hitherto employed, especially in the case of automatic recording.

The construction of shadowless Lenard windows greater than 4 by 6 cm. raises no difficulties; from the outside the cathode ray oscillograph with Lenard window resembles the old Braun tube.

Abridgment of

# A New Transmission Line Construction

## Post Type Towers

PERCY H. THOMAS[1]
Fellow, A. I. E. E.

***Synopsis.***—*The new construction described is intended to secure a sturdy and simple tower, not sensitive to irregularities in footing conditions; it is generally applicable where a horizontal arrangement of conductors is feasible. The tower consists of an articulated overhead transverse bridge carrying the conductors and hinged at the tops of the footings. Two or three intermediate towers are used between stabilizer towers. Transverse strength is secured by crossed internal ties and longitudinal stresses are taken up in the stabilizer towers by heavy guys and in the intermediate towers by the ground wires and conductors which transmit these stresses to the stabilizer towers.*

*The wide base structure thus secured has substantially no resultant uplift on the footings, offering a very large saving in foundation costs. This saving, together with the lessening of material and erecting costs, and the great ease with which it is adapted to varying ground conditions, makes this a very economical type of tower.*

CONSIDERING the wide variety of conditions under which power transmission lines are installed, the very limited number of types of structures actually used is surprising. No one type of structure,—such, for example, as the usual four-legged, rigid, narrow base, cantilever tower,—would naturally be expected to be the most satisfactory and economical design for all services and yet, except for the well-known so-called flexible type, almost no other steel tower is used. In order to discover whether a different form of line support might not have real advantages over the usual type for some services, the author has made a careful survey of the requirements and the most available alternative forms, and has worked out what may appropriately be called the "post type tower," a type contrasting sharply in a number of important features with the usual designs. It is intended primarily as a sturdy, simple structure, not requiring special skill in erection and having the most favorable electrical characteristics, together with the lowest reasonable cost.

Engineers recognize the inherent weakness of the four-footed rigid tower set on earth stubs, this being in effect, a light, exceedingly rigid structure, placed on an uncertain, non-rigid base. The difficulty of framing a wide base, rigid structure with the relatively light structural sizes available, as well as side-hill conditions, and sometimes also the value of the land occupied, has led to the development of the present narrow base tower, such towers having in many cases, especially on important high-voltage lines, a ratio of height to base most unfavorable for resisting the severe stresses imposed by high winds and broken conductors and resulting in greatly magnified vertical stresses on footings. The conditions imposed upon the foundations are particularly severe because the stresses on the footings alternate from compression to tension. If any inequality of bearing is thus developed, undeterminable but dangerous weakness is inevitably introduced. Unfortunately there is no way of discovering or remedying such inequality. It may not be unreasonable to surmise that were all the towers of the average existing transmission line subjected as they now stand to the maximum conditions of wind, ice, and broken conductors for which they were theoretically designed, many would fail. I think we may safely conclude that the very satisfactory results as to tower performance now secured are due to the fact that the severe condition asssumed in design very rarely occur.

Recent researches have shown that the height of a transmission line conductor above ground is one basic factor in determining the severity of the exposure to lightning, so that the vertical arrangement of conductors, helpful toward economy of right of way, is decidedly unfavorable from the point of view of service in country subject to lightning. Furthermore, due to widespread trouble from this source, the difficulty in sleet country of avoiding arcing due to jumping of cables with the vertical arrangement is well-known. These facts have been borne in mind in working out the new type tower.

The post type tower is fundamentally a broad base structure. Such a broad base in a transmission tower can be secured only by the use of tension members for bracing. The wide tower base and the fact that the conductors have a minimum height above ground practically serve to eliminate all direct resultant uplift on the footings.

The post type tower, which is almost equally well suited for either one-circuit or two-circuit lines (see Figs. 1 and 2), consists of a long transverse crossarm, carrying the conductors, supported near the two ends by independent upright posts, taking only axial stresses. The transverse stresses on the line are taken by internal-tension cross ties located between the posts; the longitudinal stresses, by guys. The mechanical connections between the tops of the posts and the crossarm and between the bottoms of the posts and the footings are hinged, the tops for motion in a transverse plane, the bottoms for motion in a longitudinal plane. The tension members or guys taking up longitudinal stresses

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*Presented at the North Eastern District Meeting of the A. I. E. E., Springfield, May 7-10, 1930. Complete copies upon request.*

are connected to the crossarm in the same horizontal plane as the insulator strings and are located approximately over the posts. Therefore, while the crossarm must take up in a horizontal plane the longitudinal stresses from broken conductors transferring these stresses to the guys, there is no bending thus caused in the posts. The pull of a broken cable acting on the inclined guy produces a downward component, but as the guys are connected near the post tops, little downward strain is produced in the crossarm.

Ground wires are preferably connected to the lower chord of the crossarm in the same plane as the insulator strings and substantially at the same location as the guys. They may however be connected at a higher level on the crossarm, in which case the posts will have to be designed to take up the resultant bending moment developed in a vertical plane between the ground cables and the guys.

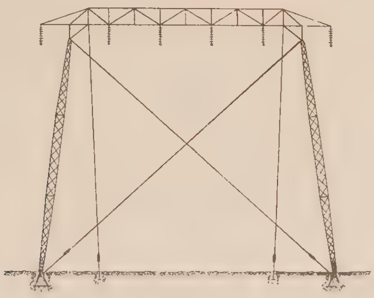

Fig. 1—Front Elevation, 132-Kv. Double-Circuit Post Type Tower Showing Guys and Cross Ties

A moment's consideration will show that this structure is exceedingly favorable for supporting conductors on earth foundations, for no settling of a post footing or yielding of a guy anchor, and no error of leveling or locating of footings or anchors, within any reasonable limit, would cause any material over-stresses in the structure. At most, a certain slackness of cross ties or guys may be caused, easily remedied by tightening turnbuckles.

In considering the field of utility of the post type tower, the question of the right of way assumes unusual importance. It will be clear that a wider right of way is required for any horizontally arranged circuits than one which would be sufficient for a line with vertically arranged conductors; therefore, where lines must be run through woods for long distances, or in thickly settled districts, the post type is at a disadvantage. On the other hand, in open fields, whether used for pasture or agriculture, in which the obstruction to the land is merely that caused directly by footings and anchors, the post type tower may even have an advantage, since the footings and anchors are so widely separated from one another that it is possible to work around them and very little ground area is actually obstructed. With the ordinary four-footed tower, the whole area between the four footings is usually lost.

The post type tower is especially notable for its sturdiness. On account of the flexible connections at the top and bottom of the posts, movements of the foundations, or stretching of guys or yielding of anchors cause no bending moments in any part of the structure. Furthermore, the stresses are all definite and calculable so that all members, including the guys, may be proportioned for their individual stresses with the assurance that no unknown and dangerous overload may be introduced by settlings of footings or irregularity of setting as with rigid towers. Further, the single heavy crossarm has a greater reliability than the usual single cable crossarms.

The post type tower is notable also for its simplicity and adaptability, manifest both in layout work and in the field. On moderate side-hill slopes, the normal towers are merely skewed up hill somewhat, and all the same material used as on level ground. On steep slopes, a taller post is used on the downhill side. A limited number of unit crossarms, posts, and guys may be combined in different ways to obtain constructions suitable for all special towers, such as angle, long span, dead end, etc. This shows the flexibility of the design.

It will be noticed that the same tower, (for example the tower shown in Figs. 1 to 2), can be used for two circuits, 110- kv. or 132- kv., at the original installation and afterward changed to one 220-kv. circuit. In the change-over, the positions of the outside conductors would be abandoned and three conductors hung between the posts instead of the four for 132 kv.

Considering installation operations, since the towers are finally trued up after erection by means of turnbuckles in the cross ties and guys, there is no reason why post footings or guy anchors should be accurately located; nor is there any object in carefully leveling the footings. Variations of a foot or two either in horizontal position or in the vertical setting of footings are unimportant.

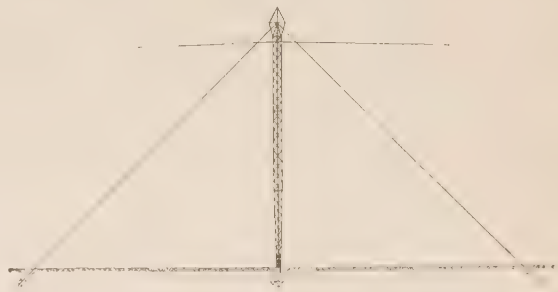

Fig. 2—Side Elevation, 132-Kv. Double-Circuit Post Type Tower

The post type tower has a further advantage in its cost saving which is very material in amount. On account of the wide base in both directions, and the articulated construction, there is a considerable saving in the cost of steel. Furthermore, on account of the absence of resultant uplift on the footings and the flexible connections, it is not necessary for the footings to be set more than three or four feet below the surface

in ordinary soil. This results in a great saving in the cost of excavation and backfill. These savings with the simpler erection and lighter weights to be transported result in a very large saving in the cost of towers erected. There cannot, of course, be any saving in the cost of conductors *per se*.

There is a modified form of the post type tower which is especially favorable from the point of view of cost and simplicity, this being especially applicable to two-circuit lines. By relying on two ground wires connected respectively near the post tops and secured firmly to the crossarm to take up longitudinal stresses, it is practicable to omit the longitudinal guys on a majority of the towers, the ground wires serving the function of the guys for these towers. In this construction, on account of the long spans, the towers will not be held strictly rigidly in position, but being hinged at the bottom, they are free to adjust themselves to the pull of the ground wires and conductor cables and no abnormal stresses are introduced. On towers where the guys are omitted, a broken conductor will cause a slight displacement of the crossarm, sufficient to tighten up on the ground wires in one span while slackening off in the other. No bending stresses are introduced in the posts and no mechanical instability.

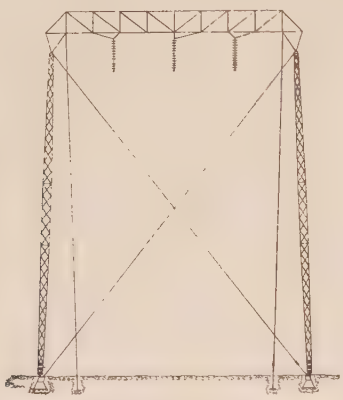

Fig. 4—Front Elevation, 220-Kv. Single-Circuit Post Type Tower

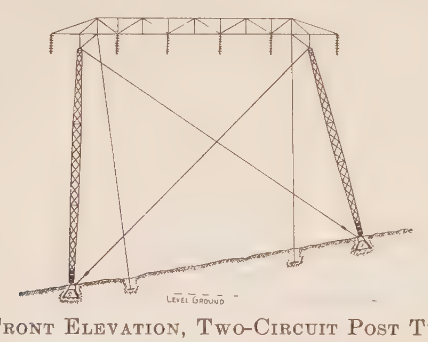


Fig. 5—Front Elevation, Two-Circuit Post Type Tower on One-in-Five Transverse Ground Slope

The construction of the tower and its use on side-hill slopes is shown in Figs. 5 and 6. The normal tower is used on a moderate side-hill slope with the crossarm parallel to the ground. A tower on a steeper side hill is provided with an additional extension in the down hill leg, as shown in Fig. 5. Where the ground slopes with the line, the tower is kept perpendicular to the ground and the guys make the normal angle with the post as shown in Fig. 6. This arrangement gives the simplest and most favorable design. Small angles can be taken on the regular tower with a somewhat wider crossarm and heavier cross ties.

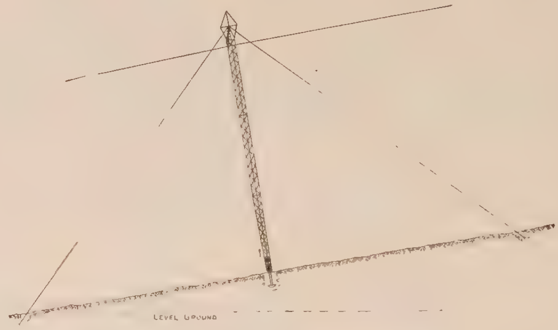

Fig. 6—Side Elevation, Post Type Tower on Longitudinal Side-Hill Slope

A tower suitable for taking a large angle in the line is shown in Fig. 7. Two pull-offs, one connected to each post, are used. Both are secured to the same anchor but through a whiffletree arrangement by which the total pull-off stress is divided between them in the desired ratio.

## Structural Design

There are many interesting design details to be considered in the post type tower, none presenting any serious difficulty. As a fundamental principle, there is a horizontal plane of resistance at the bottom of the crossarm which takes up longitudinal stresses. All longitudinally acting elements,—*viz.*, conductors, ground wire, guys, and insulators,—are attached in this plane. If this condition is not maintained, there will be a resultant tendency for the crossarm to turn on a horizontal axis, which tendency can be resisted only by stiffness in the posts. The post can be of economical design only when its load is substantially axial as bending moment greatly increases the weight of members.

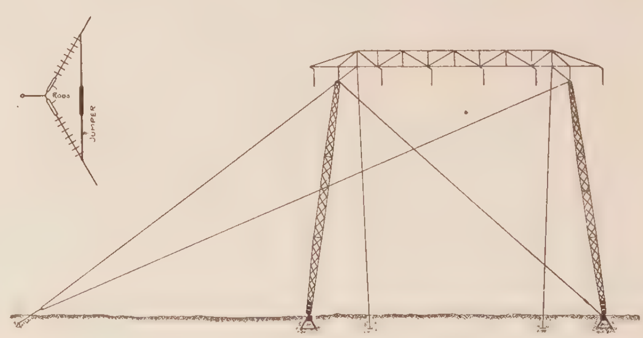


Fig. 7—Front Elevation, Post Type Tower for Heavy Angle in Line, Showing Two Pull-offs and Whiffletree

Fortunately this connecting of all longitudinally acting elements in this plane is generally favorable. The ground wire is then supported on the tower, at a point higher than the cables, by the length of the insulator string; but it is at the same time separated by a larger distance horizontally. Since the protective effect of the ground wire is increased by a location close to the conductors, this relationship is favorable. A greater separation between ground wire and cable out in the span can be obtained by drawing the ground wire somewhat tighter than the conductor, as is often done with other types of towers.

Attention should be called to the fact that the longitudinal guys of the post type tower are not to be compared to the usual twisted wire steep angle guys so much used in wood pole construction. They are tension members carrying definite, calculated stress, just as the bracing does in the usual tower. The guy anchors are designed and proportioned for their specific loads just as are the footings of the four-legged tower. There, as already stated, guy anchors are more reliable than such footings, since the stress is always in one direction and not alternating, and any yielding of the foundation is shown by the slackening of the guy, which can be easily remedied by tightening the turnbuckle without disturbing the tower.

The size of the tension rods used in post type towers is so large as to be substantial and not easily injured; and furthermore, not greatly weakened by quite severe mistreatment. The use in the common type of tower of angles as bracing subject to compression is far less advantageous from the load carrying point of view than the tension rod.

As solid rods are not flexible, special provision must be made for their convenient use. This may be secured by using the rods in fixed lengths, each length having a button upset on each end, with suitable loose socket connectors for holding them together. These connectors will give an angular freedom of from 10 to 20 deg. each, so that a complete guy or cross ties made up of several lengths will have a very considerable flexibility. Somewhat similar methods of connection are now in use in somewhat similar service and provide a very simple and economical method of developing the full strength of the rod.

Two regular lengths of rod, 25 ft. and 12½ ft., may be used to advantage. The necessary number of such rods will be specified in the drafting room for each site and listed with the tower material. In the field, the cross ties and guys will then be a few feet short. To cover this shortage, there is carried by the erecting crew an assortment of lengths varying by 1-ft. steps up to 6¼-ft., which with the long screw turnbuckles will complete the ties and guys without any cutting or fabrication in the field.

Although there is no resultant uplift of material consequence on the post footings; the windward footing must take the full transverse horizontal shear on the tower, to this extent giving an advantage to the four-legged tower, where the shear is divided between two or more footings. If the cross ties be carried down to the earth bearing parts of the footings, the shear occurs at that low level. If connected at higher points near the ground surface, there is in addition an overturning moment on the footing that must be resisted. It is important to notice, however, that a yielding of the stub to shear causes no stress in the tower unless the stub is actually pulled out of position, on account of the articulation of the tower. This is of great importance in considering the sturdiness of this design.

### Erection

The process of erecting is simple. A tower is assembled complete with insulators on blocks on the ground with the posts hinged to the footings. A divided bridle is connected to the tops of the two posts and carried over a single shear stick in the center of the line. The tower may then be raised by a windlass or truck, the guys being used as back stays. If the construction in which the guys are omitted from a certain portion of the towers is used, temporary guys may be provided until the ground cables are strung. When the structure is erected the cross ties and guys are tightened so that the structure is made taut and rigid; in fact, it is the most rigid type of tower available.

### Towers with Guys Omitted

The behavior of a line in which the guys are omitted from a certain portion of the towers on normal tangent line, as for example three towers out of four, is interesting. The most critical case is the breaking of a cable near the end of the crossarm, for example the outside conductor. In this case a stress equal to the final stress in the cable is imposed horizontally on the end of the crossarm. The horizontal broken cable stress pulls the end of the crossarm to one side until the other cables develop opposing stresses equal in amount. The principal opposing stress comes from the adjacent ground wire which is secured directly to the tower. The limiting stresses occur on long spans with ice and wind loading. As the crossarm moves to the side at the point of attachment of the ground cable, the stress in this cable increases in one adjacent span and decreases in the other, and the difference represents the pull opposing that of the broken cable. When the point of equilibrium has been reached, it will be found that the end of the crossarm where the broken cable is located has moved some two or three ft. only. The point of attachment of the broken cable is out at the end of the crossarm while the nearest ground cable is attached several feet inside. As a result, there will be a slight stress in the far ground cable in the opposite direction from that in the near ground cable. The crossarm at the far end then has a slight movement in the reverse direction.

In the case of a broken ground wire,—presumably a less likely contingency,—the same action occurs except

that the displacement of the crossarm is somewhat greater on account of the necessity of taking up the swing of the insulator string before the development of the necessary opposing pull in the several conductors. In this case, the outside conductor cable takes the greatest stress as the crossarm will as before revolve in a horizontal plane about a point near the far ground wire.

The only serious objections urged against the post type are the greater width of line structure, which is controlling in only a few cases, and the use of guys, which while exceedingly effective and economical, make a widespread base. The utility of the post type tower can be summed up very briefly as follows:

1. Sturdy and simple design.
2. No special skill or accurate leveling required in setting footings or tower erection.
3. Best arrangement of conductors electrically and as a safeguard against uneven ice loads.
4. Not sensitive to foundation movements.
5. A very material saving in weight and cost of steel and in cost of footings, anchors, and erection.

It may be added that obviously many modifications of the post type structures here shown may be made to meet different conditions or uses.

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**Abridgment of**

# Cooperative Courses—Their Development and Operating Principles

BY KARL L. WILDES[1]

Member, A. I. E. E.

***Synopsis.***—*The Cooperative Idea has been the motivating spirit in the various attempts to bring together the educational and industrial elements in engineering. The outstanding milestones of progress in this undertaking are the "Sandwich System" of Scotland, the establishment of shops in schools, the rise of educational opportunities in industrial concerns, the report of Sir William White's committee of practising engineers and educators in England, and finally, the conception and inception of the cooperative courses at the University of Cincinnati and at the Massachusetts Institute of Technology.*

*These courses are taken as examples of two types of cooperative course called respectively the "Cincinnati Plan" and the "M. I. T. Plan." Each of these possesses a structure and a set of operating principles determined by the purpose for which it was instituted and the conditions under which it is carried out. The operating principles of the M. I. T. Plan are discussed in detail in this paper. The graduates of both these plans are demonstrating that the results sought are being accomplished.*

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"THEORY is the commander,—practise the soldiers," said the far-sighted da Vinci. The cooperative idea, or the principle of coordinating theory with practise, has struggled for expression down through the ages. As time goes on, it is bound to express itself with increasing forcefulness, and at the present time effective applications of the principle are in use in this country, especially in the field of engineering education.

## The Cooperative Idea—Development

*The Antagonism between Theory and Practise.* The engineering profession arose out of the crafts, and naturally enough, the early engineering processes were the craftsman's rule-of-thumb methods. Such empirical information as was found practicable was handed down and augmented by later engineers, and thus was the fund of engineering knowledge built up. Practise, then, was the only means of entrance into this profession, and it became the custom for young men, usually with little scientific education, to serve several years as apprentices with their elders, after which they might be recognized as civil engineers. For many years the young man who had studied the then existing sciences was none too welcome in engineering circles, for he was bothersome; he had to be divested of his academic ideas before he could begin to learn anything practical. The cooperative idea was in this situation, facing the apparently insurmountable task of reconciling the practising engineering profession with the technical college, an outgrowth of the schools of science in the universities.

*Conciliatory Moves.* The first gesture of the cooperative idea in technical education was probably seen in Germany. The notion that boys finishing at the "*gymnasium*" were too immature and lacking in educational appreciation to make the most of their studies in the "*polytechnikum,*" led to the system of placing them in mechanical workshops for at least one year before entrance into the scientific school. A certain evaluation of materials and methods and an increased desire for scientific knowledge were thought to result from this practise; in fact, the results were so convincing that the plan spread into neighboring countries and, notably in the higher technical colleges of Germany and

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*Presented at the North Eastern District Meeting of the A. I. E. E., Springfield, Mass., May 7-10, 1930. Complete copy upon request.*

Scandinavia, still persists as a requirement for a degree.

The "Sandwich System" came into use nearly a century ago; not as an educational move, as some have supposed, but rather from financial expediency. According to a Scottish engineer,[2] Scotchmen of former generations could not afford attendance at the university for more than six months in the year, which explains the short six months' session of the Scottish universities. As Glasgow University was one of the first to teach engineering science, the short session and the large engineering community naturally evolved the Sandwich System, which gives the student six months at the university and six months in the workshop. There was no attempt here to coordinate the school work with that of the shops, or vice versa, but it has been remarked by employers that this type of education produces "men who can make a good living." Here the cooperative idea almost came to light.

*The Move of the School toward Industry.* Inspection and instruction trips to industrial establishments have been featured by technical schools in this country from the very first[3] (1824). In the case of Worcester Polytechnic Institute (1868), a small manufacturing plant was established on the campus. Skilled journeymen were employed and articles of commerical value were produced by students and journeymen working together. About a decade later, instructional shops were established at the Massachusetts Institute of Technology for the purpose of teaching the fundamental shop operations without consideration of factory production. Both these types persist in their respective institutions and one or the other has been adopted by practically every engineering college in this country. These, and other moves on the part of the schools to develop the industrial side were prompted by the cooperative spirit in them reaching out for the practical.

*The Move of Industry toward the School.* But the cooperative spirit also reached out from industry toward education. This is perhaps best evidenced by the establishment of courses of classroom instruction in the great manufactories, first for trades instruction, and later for engineering instruction. The classroom instruction provided by the industries has, in some cases, risen to a high type of theoretical instruction, as exemplified by the "Out-of-Hour Courses" of the Bell Telephone Laboratories, the "Advanced Course in Engineering" of the General Electric Company, and the "Design School" of the Westinghouse Electric and Manufacturing Company. The establishment of scientific research laboratories in the large companies was also a decided advance toward recognition of the closer relationship between pure and applied science.

*Eminent Engineers and Educators Express Themselves.* In 1903, a committee of very eminent British engineers[4] and educators, under the chairmanship of Sir William H. White, was appointed "to consider and report . . . as to the best methods of training for all classes of engineers; it being an instruction to this committee that the principle shall be maintained that the education of an engineer must include both practical experience and scientific training."

*The Idea Born.* None of the foregoing arrangements merits the cognomen of "cooperative education" as it is practised in its most effective forms in America at the present time. Finally, in 1906 the "idea" succeeded in breaking the shell and appearing as a reality. During the years occupied by Sir William White's investigation, Mr. Herman Schneider had conceived the scheme of coordinating engineering theory, best taught in the schools, with engineering practise, best taught in the industries, and he was having difficulty in putting his proposal into operation. Great credit is his due, however, for his persistent and energetic labors, for finally, in Cincinnati, he discovered an attractive situation in which he could launch his project. Thus came into being the world's first real cooperative course, recognized in America and in Europe alike as the birth of the cooperative idea.

## The Cooperative Idea—Operating Principles

*The Cincinnati Course—Aim.* The peculiar situation into which the cooperative idea was born had much to do with the structure and therefore with the operating principles of this first course. Cincinnati is a city of great industrial plants, like those of the present Cincinnati Grinders, the Union Gas and Electric Company, and the Cincinnati Traction Company. It is also a public-spirited city having at heart the progress of its public institutions, including its municipal university as well as its private business enterprises. It is at once evident that the local industries furnish not only exceptional opportunities for training young men and women, but for utilizing their services after they are trained. The demand upon the university, therefore, is chiefly for the production of engineers to occupy the responsible positions in these industries. To quote President Schneider,[6] "The aim of the course is not to make a so-called pure engineer; it is frankly intended to make an engineer for commercial production."

*The Cincinnati Plan—Original Structure.* Originally, the course was laid out to cover six years, alternating the student, week by week, between shop and college during the academic year of eight months, and placing him in the shops also during the four months of vacation. This arrangement gives a total of four years in the shops and 24 months in college, as compared with the 32 months of the regular four-year plan. President

2. Captain J. M. Scott-Maxwell, *I. E. E. Jl.*, Vol. 57, 1919, p. 466.

3. "History of Rensselaer Polytechnic Institute," P. C. Ricketts, John Wiley & Sons, Inc., 1895, p. 43.

4. *Inst. Civil Eng. Proc.*, Vol. CLXVI, Part IV, 1906, p. 159.

6. "The Cooperative Course in Engineering at the University of Cincinnati," Herman Schneider, *Proc. S. P. E. E.*, Vol. XV, 1907, p. 391.

Schneider reports that due chiefly to the eagerness for study engendered by the contact with shops, and to the fact that the boys did some studying on their own initiative in the industrial periods, more, rather than less, scholastic work was accomplished under the cooperative plan than under the regular one. The story of the experimental period of this undertaking is most fascinating,[7] and in it some important changes took place, as will be seen; but with only a casual reference to this story, we shall pass on to the final set-up of the course as it exists today, and we shall call this scheme the "Cincinnati Plan" of cooperative education. Several other prominent institutions, about 20 in number, such as the University of Akron, Georgia School of Technology, and Antioch College, have established courses after this plan.

*The Cincinnati Plan—Present Structure.* The present structure of the Cincinnati Plan is this: a summer practise period is advised previous to entrance to the course, and beginning with the fall term of the first year the student alternates in four-week periods between college and shops throughout the five-year course, with four weeks of vacation per year. The shop is worked by a staff of coordinators in such a way that the job whose chief values lie in shop discipline and simple operations are given to the freshmen, and those requiring more judgment and training are given to the upper classmen. These coordinators also hold classes in coordination at the University and visit the men on the job, in both cases answering questions and pointing out important practical and theoretical aspects of the jobs. In some cases, the employment may be all with one concern; but in cases where the work supplied by one company is not sufficiently extensive, the student may be moved to other companies. Jobs at the plants are kept filled by the principle of alternation in pairs, one or the other of the students of a pair being held responsible for filling the job at all times while this pair is assigned to this job. No university classes are held for the students at the shops, but a comprehensive report is required of each student upon his return to the University.

*The M. I. T. Plan—Inception and Purpose.* A plan involving a more intimate application of the cooperative idea, differing from the Cincinnati Plan in purpose and scope, and therefore in operating principles, was developed for electrical engineering conjointly by Mr. Magnus W. Alexander, (then of the Lynn Works of the General Electric Company,) and Professor Dugald C. Jackson, (of the Massachusetts Institute of Technology,) and was put into operation in 1917. The World War interrupted this initial attempt, but it was re-established in the summer of 1919 and its administration placed in the hands of Professor William H. Timbie. It was the result of ten years' observation of the Cincinnati Plan, consideration of European practises and opinions, and a careful study of the adaptation of the cooperative idea to the needs of the company and the educational facilities of both the company and the Institute. The purpose was to train a selected group of promising and scholarly young men for the technical and executive positions of the electrical manufacturing industry. It was apparent that the academic training needed by such men would involve not only a thorough study of the fundamental sciences and the application of those principles to the design and operation of machines, but at least an additional year of postgraduate study in which creative ability and acquaintance with the frontiers of scientific knowledge would be developed. It was equally apparent that a prolonged and haphazard round of shop duty was a waste of time for the type of young man under consideration. For this reason, a course of Manufacturing Practise was laid out, covering the essential details of the manufacturing problem from the machine shop, through the various tests of apparatus, production offices, and engineering development and research laboratories. Furthermore, a good foundation in mathematics, physics, chemistry, English, and drawing, was seen to be necessary before entering this coordinated course in theory and practise.

*The M. I. T. Plan—Structure.* In view of the above considerations, the Cooperative Course in Electrical Engineering, known at the Institute as Course VI-A, was constructed as follows: The successful completion of the first two years of basic scientific and humanistic studies is required for entrance to the cooperative years. At the beginning of the summer following the second year, the class jointly selected by the cooperating company with which the particular students will be related for three years, and the Electrical Engineering Department of the Institute, is divided into two groups, designated Groups A and B, Group A remaining at the Institute and Group B going to the industrial plants. The groups alternate between industry and the Institute at the end of each academic term, fitting into the regular Institute calendar of studies, activities, and vacations when at the Institute, but responsible to their company during the complete term while on industrial assignments. The project includes continued scientific and general study, and instruction by members of the Institute staff, for students at the Works. The two groups are reunited at the Institute for the final term of the graduate year, during which they complete the requirements for the Master's degree. This last term, away from industry, places the student in an unbiased atmosphere at the time he is considering permanent employment, and promotes class activities preceding and including the commencement season. This plan has been called the "M. I. T. Plan," and has been adopted also by the Civil Engineering Department of the Institute in cooperation with the Boston and Maine Railroad; it is now pending adoption by one or two other institutions with good graduate departments. We shall now discuss some of the operating principles of this plan, with special reference to Course VI-A.

7. "The Cooperative System of Education," Clyde W. Park, University of Cincinnati Studies, Series II, Vol. XI, Part 1, 1925.

*The M. I. T. Plan—Operating Principles.* It is desirable, although not requisite to the successful operation of the M. I. T. type of cooperative course, that a non-cooperative course carrying in its curriculum the same scientific training, be maintained.

The cooperating company must meet the following specifications for the M. I. T. cooperation:

1. It must be large enough and complete enough in its organization, training facilities, and range of production to provide a comprehensive course in its particular field.

2. The company must be competent and willing to assume its share of the responsibility in the administration of the project.

3. The company must have a specific need for the type of man trained. If this is not the case, it is training men only for competitors, or at best, for other concerns.

These specifications are believed to be met by the companies associated with Course VI-A, each company occupying a prominent place in a special field of electrical engineering. The General Electric Company gives an unexcelled course in Manufacturing Practise, including shop work, testing of electrical and mechanical apparatus, factory production studies, and development and research on products and manufacturing processes. The Public Utility Practise is given in any one of three companies—the Edison Electric Illuminating Company of Boston, for generation and utilization of electric power, the Boston Elevated Railway, for electric transportation, and Stone & Webster, Inc., for the planning, construction, and operation of various kinds of power projects. The Communication Practise is given by three component companies of the Bell System,—the Western Electric Company, Inc., in the manufacture and installation of communication apparatus, the New York Telephone Company, in the maintenance and operation of telephone plant and the Bell Telephone Laboratories, Inc., in the development and research in communication engineering, the relation to the three communication companies being coordinated by the American Telephone and Telegraph Company.

Similarly, the educational institution must match the above specifications with the following:

1. It must maintain an adequate and competent staff of teachers, administrators, and scientific investigators, classroom and laboratory equipment, and undergraduate and graduate educational program sufficient to provide the technical and cultural groundwork for the engineering profession.

2. It must, of course, not only carry the entire administration of the course while the students are in academic residence, but must also enter thoroughly into the cooperative spirit in the administration of both the academic and practical content of the curriculum.

3. The educational institution must not be situated too far away from the cooperating industries.

Before a student is accepted for this cooperative course of training, he must complete successfully the first two years of groundwork in mathematics, physics, descriptive geometry, drawing, chemistry, and English. These have been termed the a b c's of engineering and ought to be well in hand before the principles of design and operation of electrical and mechanical apparatus are undertaken.

Late in the sophomore year, the candidates recommended by the Department of Electrical Engineering of the Institute are interviewed by representatives of the company with which the cooperative training is desired. The qualifications sought by these company representatives are in general the same as those considered important for regular permanent employment. The mutual obligations of student and company cease, however, at the end of the course.

The rates of pay for students in cooperative training are substantially uniform among the companies, slight compensations being made for variations in living expenses in different localities. In order to insure the transfer of students from one job to another on the basis of the best educational value, it is held to be essential that the rate of pay be fixed according to the class in which the student is registered, rather than determined by prevailing rates for the kind of work he does.

During the practise periods, additional studies are required to the amount of eleven hours per week, classroom and study. Two subjects are conducted by members of the Institute staff on two afternoons or evenings each week after working hours. One of these subjects is given by the Department of Electrical Engineering and is classed as a scientific subject; the other is given by the Department of English and History and is classed as a humanistic subject. Thus, the "Principles of Electrical Engineering" are studied almost continuously during the cooperative years, and such cultural subjects as "Modern Forms of Literature" are given while the men are in the more practical atmosphere of the plants.

Close coordination must be maintained between the two kinds of work, academic and practical. This does not mean necessarily that every practise period must contain the practical application of the scientific principles of studies during the next preceding term; in fact, in some cases it is desirable to reverse this order and make the contacts with certain apparatus a stimulus for the study of its principles of operation. This is not, however, an argument for a general laxity in coordination of theory with practise.

Vacations average about five weeks a year during the cooperative years, and students are encouraged to take full advantage of these periods for rest and recreation. A vacation period never precedes an Institute term. This allows the student to take full advantage of the

mental activity engendered by the two subjects pursued at the plants, as he swings into a full schedule of academic study.

*Values of the Project.* The ultimate value of the course to all parties concerned is best measured by its value to the students. Some of the chief benefits to the students are as follows:

1. The regular four-year undergraduate course in Electrical Engineering plus an academic year of graduate study are accomplished in five years without condensation of Institute schedules. The Master of Science and Bachelor of Science degrees are awarded for this work.

2. In addition to the scholastic attainment, each student spends 15 months during the three years just prior to graduation in a well-ordered course of practical training with one large company, where he learns to correlate fundamental scientific principles with their method and scope of application.

3. The opportunity to study the personnel relationships in organized industry provides a real course in industrial psychology, which should develop in the student a sound philosophy of organization and management.

4. A company loyalty is developed which is essential to the young man's progress and his value to any organization in which he is employed.

5. The whole cooperative scheme forces the student to evaluate his own personal characteristics, such as tact, persuasiveness, creativeness, cooperative ability, mechanical aptitude, and power of concentration, thus tending to improve his personality.

6. Valuable habits of evening study, which persist after the young men leave college and obtain responsible positions in engineering, are attained.

7. Valuable acquaintances with leading figures in a great industrial organization are formed.

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**Abridgment of**

# Transformer Ratio and Differential Leakage of Distributed Windings

BY R. E. HELLMUND* and C. G. VEINOTT†
Fellow, A. I. E. E. Associate, A. I. E. E.

***Synopsis.***—*This paper develops in as simple a manner as possible the necessity for the concept of "differential leakage" where transformer action takes place between two unequally distributed windings and explains the character of differential leakage. The value to be used for the transformer ratio in the case of such unequally distributed windings is also given. All considerations are based on the conventional stepped wave field forms, and the mathematics used involve only the simplest linear equations. While in nature, the paper is mainly intended to be expository a general indication is given at the end as to how differential leakage and transformer ratios can be calculated for both single-phase and polyphase arrangements.*

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## Introduction

In many a-c. motors in which transformer action takes place between two windings, certain problems arise in determining the proper transformer ratio for the two windings, due to the fact that for various reasons the two windings are not distributed or arranged alike over the circumference. Furthermore, it is found expedient in such cases to introduce the concept of "differential leakage" in order to make the motors and their transformer actions subject to the ordinary analysis and calculating methods used for transformers.

Although Adams[3] called attention to the existence of differential leakage under the name of "belt leakage" as early as 1904, the nature of this phenomenon seems to be very little understood even today. Considerable confusion has also been caused by the fact that quite a variety of names has been applied to the same phenomenon. Adams calls it "belt leakage;" Hellmund and Krondl, "differential leakage;" Rogowski and Simons, "doubly-interlinked leakage;" Sumec, "unequally-interlinked leakage;" and Baffrey, "voltage of the higher harmonics." Further complication has arisen because with some methods it is more convenient to derive the combination of differential leakage and what is known as "zigzag" or "tooth-top leakage," and as a result, differential leakage has sometimes been referred to as part of the zigzag or the tooth-top leakage and the like. In view of this situation, this paper is offered principally as a contribution to clarify certain points regarding the transformer ratios for distributed windings, to set forth and explain the concept of differential leakage, to demonstrate the need for this concept in certain cases, and to show how it is comparable to other

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3. For references see Bibliography, complete paper.

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forms of leakage. The considerations used are based on the conventional stepped wave, representing field forms with which every electrical student is familiar; and although it has not been found possible to avoid mathematics entirely, those used are of the simplest kind, involving nothing but a few simple equations with one or two unknown quantities.

### CONCENTRATED AND EQUALLY DISTRIBUTED WINDINGS

Leading up to the case of unequally distributed windings, brief reference may first be made to concentrated and equally distributed windings. The simplest example of concentrated windings, magnetically coupled, is that found in transformers. In this case, there is always some flux which links only one winding in addition to the flux common to both windings. The former flux is called "leakage flux", and it is very easy to obtain a correct physical concept of it. Moreover, in such a case, the transformer ratio is simply the ratio of turns. The various relations are generally well known. By using the leakage coefficient, and the ordinary conception of transformer ratio, it is possible to calculate the voltages or currents in either winding regardless of which of the windings is used as the primary; and it is also easy to determine the various relations between


FIG. 1—EQUALLY DISTRIBUTED WINDINGS

currents and voltages when the secondary is open or when it is short-circuited.

The relations are equally simple if the two windings are distributed either evenly or unevenly over the circumference of a motor, so long as the distribution and general arrangement is the same in both windings, as shown for example in Fig. 1. Here again, the transformer ratio is simply the ratio of the number of turns. It will be seen that in this figure there is always a wound secondary slot opposite a wound primary slot, and the ratio of turns is the same in all pairs of opposite slots; that is, in this particular case 2 to 1. It is also evident that the field set-up will have the same field form regardless of whether it is built up by the primary or by the secondary winding.

It is thus seen that, neglecting slot and coil-end leakages, if either of the windings is excited, the voltage ratio of the two windings is the same as the ratio of the turns, and the current ratio is the reciprocal of this ratio.

Furthermore, if we assume the secondary winding as short-circuited and having zero resistance and zero leakage reactance, the voltage induced in it must be zero. The currents in the two windings flow in opposite directions, and so the resultant field as a whole, as well as at all parts of the gap surface, is zero. The voltage induced in the primary winding, if the latter is without resistance or leakage reactance, is zero as well. Thus, with concentrated or equally distributed windings, the ordinary ratio of turns is sufficient for all ordinary calculations, and the concept of differential leakage in such cases is not needed, since the phenomena coming under this name do not exist.

### UNEQUALLY DISTRIBUTED WINDINGS

For the purpose of studying how these conditions change in the case of two unequally distributed windings, a very simple arrangement of this kind, as shown in Fig. 3, will be considered. To bring out more clearly the points to be made, it is assumed that the primary and secondary have the same number of slots and that such slots are opposite each other. This eliminates the possibility of any so-called zigzag or tooth-top leakage, and thus avoids any complication which would be introduced by its existence. The ratio of turns is again assumed to be 2 to 1, but the distribution of the turns is different in the two windings, as shown in the figure.

*Open-circuit Conditions.* With these assumptions for the unequally distributed windings, some of the same relations which were previously determined for the equally distributed windings will now be studied.

(a) Ratio of currents producing the same total flux: The total flux produced by a distributed winding is equal to the flux which would be produced if all the turns in the distributed winding were concentrated in the outermost slot, multiplied by the magnetization factor.

Therefore,

$$k_{m1} \times I_1 \times T_1 = k_{m2} \times I_2 \times T_2$$

or

$$\frac{I_1}{I_2} = \frac{k_{m2}\, T_2}{k_{m1}\, T_1} \tag{5}$$

if $T_1$ and $T_2$ are the numbers of turns in winding $P$ and $S$ respectively.

In our particular case, we find

$$\frac{I_1}{I_2} = \frac{0.625 \times 4}{0.758 \times 8} = 0.417 = \frac{1}{2.4} \tag{6}$$

In other words, the ratio of the currents producing the same total air-gap flux is 1 : 2.4, while the ratio of the actual turns is 2 : 1.

(b) Ratio of open-circuit voltages,—winding $P$ excited: The voltage induced in either winding is proportional to the total number of turns multiplied by the voltage factor $k_p$, a factor which takes into account both the distribution of the air-gap flux and the distribution of the turns in the winding. The ratio of voltages is, therefore,

$$\frac{E_1}{E_2'} = \frac{T_1 \times k_{p1}}{T_2 \times k_{p2}'} \tag{7}$$

As shown in Equations (**65**) and (**66**) of Appendix II of the complete paper, $k_{p1}$ and $k_{p2}'$ are equal to

0.8333 and 0.75, respectively, for this particular arrangement of coils; and so the ratio of voltages becomes

$$\frac{E_1}{E_2'} = \frac{8 \times 0.8333}{4 \times 0.75} = 2.222 \tag{8}$$


FIG. 3—UNEQUALLY DISTRIBUTED WINDINGS

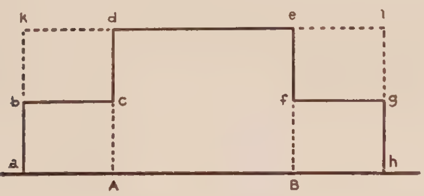


FIG. 4—FIELD FORM OF WINDING *P*, FIG. 3

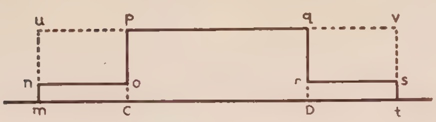


FIG. 5—FIELD FORM OF WINDING *S*, FIG. 3

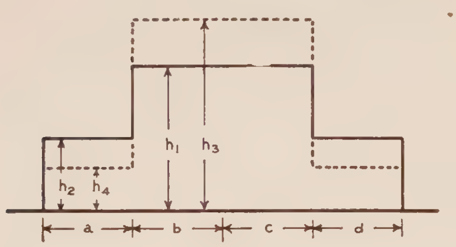


FIG. 6

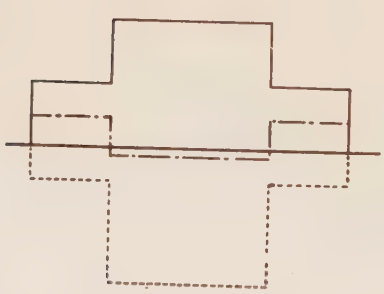

FIG. 7—FIELD FORMS, *P* EXCITED, *S* SHORT-CIRCUITED

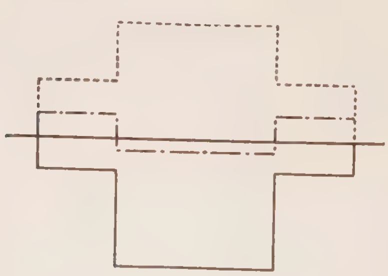

FIG. 8—FIELD FORMS, *S* EXCITED, *P* SHORT-CIRCUITED

(c) Ratio of open-circuit voltages,—winding *S* excited. In this case the voltage ratio is

$$\frac{E_1'}{E_2} = \frac{T_1 \times k_{p1}'}{T_2 \times k_{p2}} \tag{9}$$

Using the voltage factors found in Equations (**67**) and (**68**) of Appendix II of the complete paper, this ratio becomes

$$\frac{E_1'}{E_2} = \frac{8 \times 0.90}{4 \times 0.85} = 2.11765 \tag{10}$$

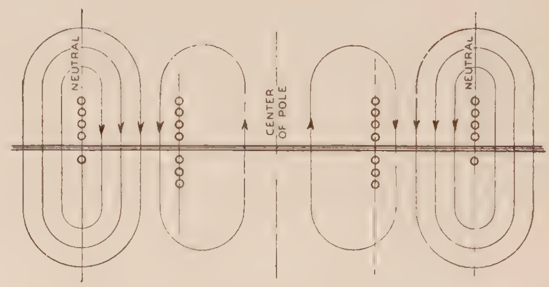


FIG. 7A—LINES OF FORCE FOR CONDITIONS OF FIG. 7

Thus far, the following has been established:

1. Ratio of total turns $= 2.00$
2. Ratio of currents producing the same total field $= 0.417 = \dfrac{1}{2.4}$
3. Ratio of voltages if the field is built up by currents in winding *P* only $= 2.222$
4. Ratio of voltages if the field is built up by currents in winding *S* only $= 2.11765$

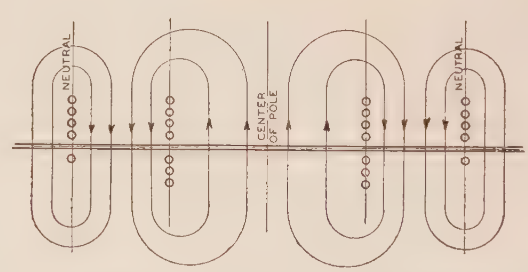


FIG. 8A—LINES OF FORCE FOR CONDITIONS OF FIG. 8

It is obvious from this comparison that the calculations just made give no definite indication regarding the proper value to be used for the transformer ratio with these unequally distributed windings.

*Short-circuit Conditions.* A study of the short-circuit conditions will indicate how these apparent discrepancies can be eliminated.

First, let it be assumed that the secondary winding *S* is short-circuited and that as before, its resistance and leakage reactance caused by slot and coil-end leakage can be neglected. Under these assumptions, the net

voltage induced in this winding must be zero. The currents in the two windings will therefore assume such values as to satisfy this condition. By means of simultaneous equations, it is found that the ratio of currents which makes the secondary voltage equal to zero is

$$\frac{I_2}{I_1} = -2.11765 \tag{16}$$

With this information, the field forms can be shown to scale, as has been done in Fig. 7.

We see that while the resultant voltage induced in the secondary winding is zero, there is nevertheless a resultant flux mutual to both windings as shown by the dot-and-dash lines in Fig. 7; the actual corresponding lines of force are indicated in Fig. 7A. This flux has both positive and negative portions in the air-gap of the same pole face, but the positive portions predominate, and so the total resultant flux is positive. The reason why this flux induces no resultant voltage in the secondary winding is simply that the smaller negative portions interlink with three turns, while the total resultant flux, which is larger and positive, interlinks with but one turn; the negative voltage induced in the three inner turns is exactly equal and opposite to the positive voltage induced in the outer turn. With a primary winding ($P$) distributed in a different manner, the negative voltage induced in the four inner turns only partly neutralizes the positive voltage of the four outer turns, and so there is a definite positive voltage induced in the primary winding just as there would be if there were a leakage flux interlinking the primary winding. In other words, the resultant flux existing under the assumed short-circuit conditions, although interlinking with both windings, has the same effect as a leakage flux in so far as it induces a resultant voltage in only one of the windings; it may therefore be treated the same as a true leakage flux for all practical purposes. Since it is caused by the difference in distribution or arrangement of the windings, it may be called "differential leakage flux." As will be seen, the study of this flux and its characteristics has been materially facilitated by the investigation of the short-circuit condition. The reason for this is that, with this condition and the other conditions chosen, there is no flux other than the differential leakage flux in existence, and as a consequence, it is possible to obtain a true picture of the phenomenon, without having it obscured by the presence of any other fluxes.

*Differential Leakage Coefficient.* We have found that there is a voltage induced in the primary winding when the secondary is short-circuited. Let us find the voltage induced in the primary when the same current is passed through it with the secondary open. The ratio of the former voltage to the latter, we shall call the "differential leakage coefficient," for in a transformer this ratio is numerically equal to the total leakage coefficient, as is shown in Equation (**62**), Appendix I of the complete paper. For these two windings this ratio is

$$\frac{E_{1s}}{E_1} = 0.047 = \sigma \tag{22}$$

which is the differential leakage coefficient.

We can also determine the differential leakage coefficient by short-circuiting $P$, applying a voltage to $S$, and proceeding in a similar manner but the same result will be obtained.

*Transformer Ratio.* There are numerous equations tying together the relations between the transformer ratio and the leakage coefficient of an ordinary transformer with leakage. For reference these equations are given in Appendix I of the complete paper. If we put the value of differential leakage coefficient just found, (namely 0.047), into any of them, we obtain the same transformer ratio (namely 2.17), for these two windings, in every case.

Moreover, if we now consider the two windings as an ordinary transformer with a turns ratio of 2.17 and a leakage coefficient of 0.047 and figure the ratio of open-circuit voltages, we find this to be 2.222 if winding $P$ is excited, or 2.11765 if winding $S$ is excited,—which we know from previous work to be correct. Even more convincing is the fact that the ratio between the currents, regardless of which winding is excited (the other winding being short-circuited, of course) can be found by using this transformer ratio and differential leakage coefficient in the proper equations derived for a transformer.

## Conclusions and General Discussion

Thus we see that by introducing the concept of differential leakage and by determining a differential leakage coefficient as shown, it is possible to derive a transformer ratio for distributed windings which applies to open-circuit and short-circuit conditions in either direction. The method previously shown for determining the differential leakage coefficient by finding the ratio of short-circuit and open-circuit voltage for the same primary current, Equation (**22**) may be used for single-phase motors in general; also, the transformer ratio may be determined as indicated in Equations (**27**) and (**29**) of the complete paper.

However, after the concept of differential leakage coefficient has been established and the nature of the differential leakage demonstrated, it is possible and frequently easier to compute the differential leakage coefficient from the no-load voltages.

For polyphase motors, the same general principles apply and the same general methods of calculation may be used. However, there is one condition existing in polyphase motors which does not occur in the ordinary single-phase case. In polyphase motors differential

leakage may occur even though the slots and turns may be equally distributed in the two members. This is due to the fact that in a wound-secondary polyphase motor, for instance, the rotor can assume positions where its phase belts do not coincide with those of the stator, as indicated for a three-phase motor in Fig. 9. With the phase belts thus displaced, the conditions in the two members are not equal; as a result, the fields set up by the two windings are different for any given axis, which, in turn, is the cause of differential leakage. It was this type of leakage caused by the difference in the phase belts that Adams[3] first pointed out under the name of "belt leakage."

The practical importance of the differential leakage varies considerably with the case under consideration. We have pointed out that it is present with any arrangement where the two windings are unequally arranged either on account of the distribution of the turns or the position of the phase belts, or on account of both. It may further be pointed out that differential leakage may even exist in a single winding with primary and secondary taps. A practical example of this kind is the armature of a frequency-changer of the commutator

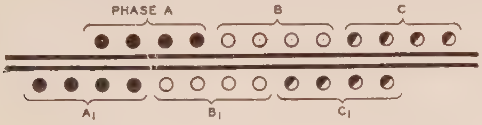


Fig. 9—Displacement of Phase Belts in a Three-Phase Machine

type where certain taps are connected to slip-rings and the other end of the winding to the commutator. For any position of the armature where the commutator brushes do not happen to be in the same location as the taps to the slip-rings, there will be differential leakage.

Generally speaking, the more the field forms of the two windings or of the same winding with different taps differ from each other, the larger the differential leakage will be. An appreciable difference will be found in single-phase commutator motors, for instance, where the armature has a single set of brushes with a full-pitch winding resulting in a triangular field form, while the stator is wound to give it a trapezoidal field form or is arranged so as to approach a sinusoidal field form rather closely. Another case where differential leakage can be very appreciable in single-phase motors is where there is transformer action between an armature coil short-circuited by a brush and a distributed stator winding. The short-circuited armature coil gives a rectangular field form which differs considerably from the field forms set up by distributed stator windings.

In three-phase induction motors with the most favorable chording, differential leakage can be made almost negligible, while with full-pitch three-phase windings, it is often of practical importance. In two-phase motors, it is generally larger than in three-phase motors, and with full-pitch two-phase windings, it may be of great practical importance. Another instance in which differential leakage can be quite large is that of two-phase motors operated with a three-phase secondary. In most cases, the relative importance of differential leakage is of course governed by its magnitude relative to that of the other types of leakage fluxes. Thus, in small slow-speed induction motors, where the other types of leakage are very appreciable, the differential leakage will very often be of negligible quantity. On the other hand, in large high-speed motors, where the other leakages are relatively small, the differential leakage may be, and frequently is, of practical importance.

## THE ELECTRICAL ENGINEER AND THE ELECTRONIC TUBE

By Prof. Harold B. Smith, *President*
American Institute of Electrical Engineers

The vacuum tube is rapidly coming out of the category of signaling devices, and is developing on to a scale where it is capable of handling quantities of power which make it a real tool for the electrical engineer. With tubes now being built with ratings of from 100 to 200 kilowatts, one may see that the electronic era of power equipment is indeed opening up.

Possessing extraordinary versatility in rectifying, converting, changing frequencies, regulating, controlling, and performing other complex functions, the vacuum tube presents a new and valuable tool for the electrical engineer in the practise of his profession. It has developed most rapidly within the past ten years, the era of radio broadcasting, as a direct outgrowth of the tremendous volume production of vacuum tubes for radio purposes. Because of this sudden advent, many electrical engineers of the present generation have overlooked its possibilities in purely electrical applications. But the younger group of engineers, particularly those who have had experience in radio, are pressing forward with this vacuum-tube development and the new branch of electronics must soon take its place alongside and coordinate with the older school of electromagnetic machinery.

Not only will the tube supplement and replace tons of moving machinery for converting and transforming power, but it will find uses in switching high-tension currents and as a lightning arrester for protection of lines.

In fact, as the result of the tube's advent, we are likely to witness a complete re-design of our electrical systems in many respects.

The electrical engineer of 1930 is therefore giving increasing attention to the whole field of electronic action in vacua, for through the developments here being made, he foresees the even wider expansion of the instrumentalities with which he works.—*Electronics*, June, 1930.

# ILLUMINATION ITEMS

Submitted by
The Committee on Production and Application of Light

## A PRE-SET PROPORTIONAL DIMMING SWITCHBOARD FOR THE THEATER

E. B. Kirke

When, in an attempt to escape the dominance of the elements, the play first moved under a roof, it was forced to accept the limitations of artificial illumination. Originally, of course, only visibility was demanded, and the flambeaux and brazier torches then available were adequate. The introduction of gas (Lyceum Theater, London, 1803) greatly simplified stage lighting, since it made possible a central control, permitting an operator, by means of valves at one point, to control all of the lights on the stage. The introduction of the incandescent electric lamp was responsible for great technical advance in the art of stage lighting, mainly because of the methods evolved for controlling intensity and for coordinating the action of many lights.

Light's inestimable contribution to the theater is the illusion of reality. This is accomplished by controlling the light pattern (distribution) as to its intensity, color, and form. In addition to designing with these qualities statically, the artist must have the power of changing them as the action of the play advances. The transitions may be sudden or very gradual, thus demanding a flexible system of central control and some means of coordinating the action of all of the resistance units or dimmers. The present method of attaining coordinated action is limited to a mechanical system of interlocking which permits group movements; that is, the individual dimmers can be locked in on a shaft that runs the length of the bank; and when thus locked, will move with the shaft when it is turned by a master handle. This does not permit of individual movement of the dimmers, for all that are locked in must move at the same speed.

The time element is of great importance in the theater. For this reason it is desirable to have pre-setting,—setting the switchboard for an effect in advance in such a way that when the cue comes the effect can be accomplished by the manipulation of a single master switch or lever, irrespective of the number of dimmers used and the manner in which the individual dimmers must move. What is called pre-setting now is attained by means of interplugging or interswitching, allowing any of the stage lights to be connected with any of the switchboard dimmers. Under this system, however, there is no pre-setting of the intensities.

It was to meet the demand for greater flexibility and to make possible a more positive control by eliminating in large part the element of variation due to the operator that the pre-set proportional dimming switchboard herein described was designed. The pre-setting allows the operator to "set-up" the dimmers in advance (two pre-settings are possible on the board which has been built, although with additional mechanism, several more are possible so that when he receives the cue for the effect in question, by operating a single master control or handle, he can accomplish the entire change. With two pre-settings, it is possible to pass on to a second effect at any time, and while the second effect is being used, the first pre-set can be changed and left in readiness for the next change. Thus it is possible to set-up always one effect in advance and to go through the lighting sequence of an entire performance with a surety and speed that is impossible with the present interlocking boards.

The proportional feature of the mechanism allows each dimmer to move at its own rate either up or down; that is, each dimmer receives motion that is proportional to the distance it must travel from its setting of the moment to its new setting. It is possible to move from any set-up of the entire board to any new set-up whenever the cue for the change comes by merely moving a single control or master handle, obtaining a perfectly smooth transition from one to the other, for all of the dimmers will start moving at the same instant and all will arrive at their respective new positions simultaneously. One operator can accomplish any transition smoothly and quickly and with the certainty that every time the effect will be the same irrespective of the number of circuits. (The board described here has only six dimmers but the principle of course can be extended to any number.)

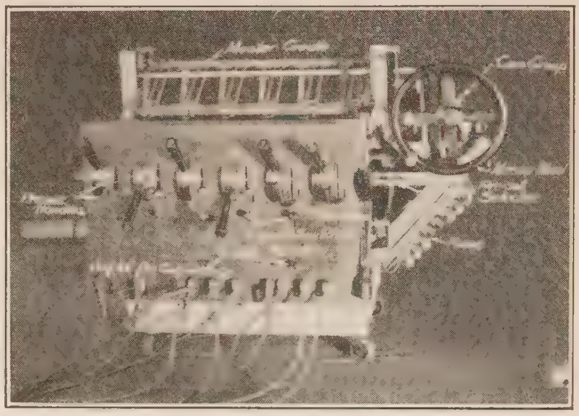

Fig. 2—The Wiring Diagram

The problem involved with the circular plate type of Ward Leonard dimmer used, (the settings of which are controlled by means of individual handles mounted on the face of the board, change from full up to down being accomplished by a movement of approximately 80 deg.), was to transmit to each dimmer from some master driving mechanism motion which would be proportional to the distance (angular) which the dimmer would have to move through in order to reach its new predetermined setting, this new setting being either in advance or behind the setting of the moment. Also, if there were to be two pre-settings possible, some selec-

tor device would be necessary to select the pre-setting wanted at that moment.

It was decided to attain these ends mechanically, although both hydraulic and electrical methods were considered. (This does not refer to the method used for driving the master mechanism, but both of these methods can be used for that purpose.) A differential linkage for each dimmer was used to vary the length of the lever arm through which the dimmer received its motion from the master driving mechanism, the linkage setting the lever arm in proportion to the angular difference in setting between the dimmer handle and the pre-set handle. In this way, for a given angular movement of the master driving handle, each dimmer receives motion proportional to the distance it must move to reach its pre-set handle.

The addition of the pre-set mechanism to the ordinary board does not in any way limit its action; all of the usual actions are maintained, the individual dimmers being free to function in the usual manner, or mastered together only when required. Also, if, duringt he mastering, individual action of any plate is desired, it can instantly be dropped from the group. If preferred, the usual mechanical interlocking can still be retained. In other words, all of the advantages of the usual board

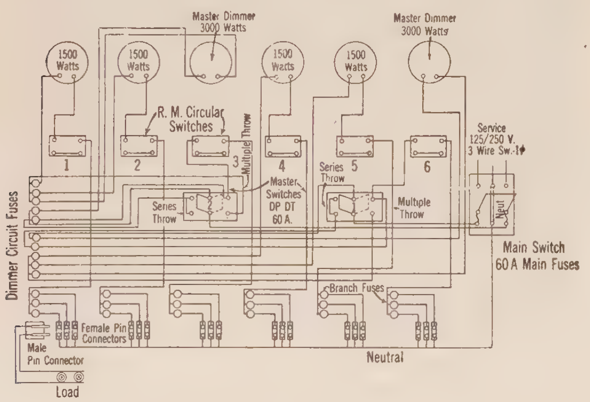


Fig. 1—The Pre-set Mechanism

are available, and to these are added the pre-setting with proportional dimming.

In the above form, a switchboard is semi-automatic; any complicated sequence can be run through, but an operator must start each change. The action, however, can be made fully automatic, it being necessary only to start the action of the board, when the mechanism will go through any number of changes that might be required. Of course since the playing varies slightly from one performance to another, this is not possible with the ordinary stage play, but for arbitrary lighting for display purposes or for moving picture theater presentations involving complicated color changes, the action could be made entirely automatic, and by adding on the face a mechanism for electrically setting the pre-set handles, the lighting for an entire play or revue could be controlled by means of punched cards. If the theaters had similar boards, these cards could be sent from one theater to another. This would also make remote control possible.

At the present time, it is not thought desirable to have all of the dimmers on a theater switchboard equipped in this way, but one group of pre-set proportional dimmers is a highly desirable addition. On a board of one hundred plates, say, 15 or 20 should be grouped together, having the pre-setting and proportional driving mechanism. With such a group, (consisting in part, at least, of high-wattage plates) and with some means such as is now in use, of interswitching at the board so that various sub-groups of the ordinary plates can be mastered electrically by the plates of the pre-set group, a highly flexible arrangement would result.

The electrical layout is given in the wiring diagram. The board which was constructed consisted of six Ward Leonard multi-capacity dimmer plates, four 1500-watt plates and two 3000-watt plates. The multi-capacity feature allows a small wattage light to be dimmed completely out, even on the 3000-watt plate. The six plates were arranged in two groups of three, with each group consisting of one 3000- and two 1500-watt plates. The wiring is such that by means of a master switch for each group, the plates can be used separately, or the two 1500-watt plates of each group can be mastered by the 3000-watt plate. The face equipment included also a switch for each circuit. Three outlet plugs (female pin connectors) were tied in on each plate circuit, allowing three load circuits to be plugged in on each dimmer. The fuse panel is mounted on the end of the board with a service switchbox. The face arrangement can be seen in the illustration.

The pre-setting of a switchboard, with the possibility of proportional dimming, will increase the sureness and the ease of operation of the board. It does not limit the operator in any way, but, on the contrary, brings in new possibilities for both quick changes and slow transitions, and the director or artist designing in light can use the medium with a greater freedom and with the assurance that no matter how involved the sequence, once he has decided on his effects, they will be reproduced at every performance in exactly the same way.

The original bank of six plates, to which was added the pre-set proportional driving mechanism, was donated to the Yale University Theater for purposes of research by the Ward Leonard Electric Company. The switches, fuses, and face equipment were made up and given by the Trumbull Electric Company.

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The electrification of the Reading railroad is progressing rapidly and it is expected that the first electrified section, the Philadelphia-Lansdale branch, will be in operation by July, 1931. Following this, the electrification of part of the main line and one or two other branches will be undertaken. A contract for purchased power has been made with the Philadelphia Electric Co. covering a period of twenty years. Current for the operation of trains will be supplied at 12,000 volts, single-phase on overhead wires.

# Institute and Related Activities

# A.I.E.E. Summer Convention, Toronto, Canada

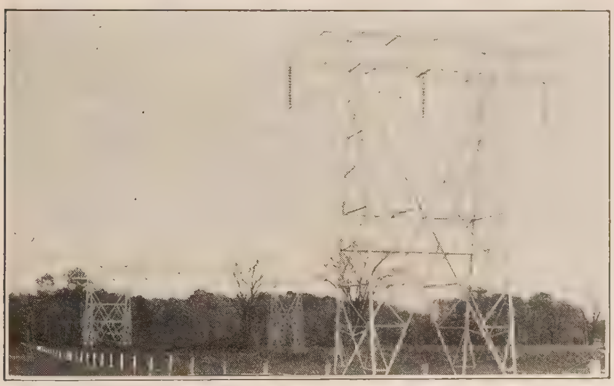
## June 23-27, 1930

### EXCELLENT TECHNICAL PROGRAM, PLEASANT ENTERTAINMENT, AND OPPORTUNITY TO RENEW OLD ACQUAINTANCES.

TORONTO is spread out along the shores of Lake Ontario, which is a link in the great fresh-water chain extending from the Atlantic to the heart of the continent; thus it offers much of interest in connection with inland navigation as well as aquatic sports of all kinds. The city is located within convenient traveling distance of the most densely populated portions of the United States, and many members who have not hitherto visited Toronto will find there much of unusual interest.

An important technical program, delightful entertainment and ample facilities for sports, together with an opportunity to renew old acquaintanceships, are offered to those who attend the 1930 Summer Convention, which will be held, with headquarters in the Royal York Hotel at Toronto, Canada, June 23-27.

The Meetings and Papers Committee has prepared a schedule of subjects covering a wide diversity of interest. This material will be presented in eight technical sessions as follows: Protective Devices—Symposium on Transmission Line Relays; Transportation; Automatic Stations; Selected Subjects and Technical Committee Reports; Transmission; Symposium on Coordination of Line, Station, and Apparatus Insulation; Communication; and Electrical Machinery and Power Generation.



220-Kv. Line, Approaching Toronto

The Symposium on Coordination of Line, Station, and Apparatus Insulation, sponsored by the Subcommittee on Transformers and the Subcommittee on Lightning, consists of seven papers written by prominent engineers from both operating and manufacturing fields of the electrical industry. The results of their efforts together with the discussion brought forth at the session should be a valuable contribution to electrical engineering, and should form a starting basis for coordinating insulation standards.

In addition to the above symposium, many other valuable and interesting papers are on the technical program.

The annual reports of the Technical Committees of the Institute will review the advances in theory and practise of electrical engineering throughout the year.

The business side of the Convention will include the Annual Meeting of the Institute, a report of the Committee of Tellers on Election of Officers for 1930-1931, a report on Constitutional Amendments, the President's Address, and presentations of prizes for papers.

The Conference of Officers, Delegates and Members under the auspices of the Sections Committee and Committee on Student Branches, constitute an important feature of the Convention.

The Lamme Medal, awarded several months ago, will be presented to R. E. Hellmund, of East Pittsburgh, Pa., "for his contributions to the design and development of rotating machinery."

On Wednesday there will be a Directors' luncheon and meeting.

The Local Convention Committee has arranged a series of events which will provide interest and pleasure for all available time throughout the entire convention. Particularly should it be noted that the following program calls for the Convention to get into full swing on Monday morning; members are urged to arrive early and register promptly.

#### OUTLINE OF PROGRAM

(Eastern Daylight Saving Time)

Monday, June 23

| | |
|---|---|
| 9:00 a. m. | Registration |
| 10:30 a. m. | Annual Business Meeting of the Institute<br>Address of Welcome<br>Annual Report of Board of Directors (in abstract), F. L. Hutchinson, National Secretary<br>Report of Tellers' Committee on<br>(a) Election of Officers; Introduction of and response from President-Elect<br>(b) Constitutional Amendments<br>Presentation of Prizes for Papers<br>Presidential Address, Harold B. Smith |
| 2:00 p, m. | Conference of Officers, Delegates, and Members<br>Qualifying Round for Mershon Trophy<br>Tennis<br>Ladies' drive about City followed by afternoon tea at Granite Club |
| 4:30 p. m. | Afternoon Tea |
| 9:00 a. m. | President's Reception—dancing |

Tuesday, June 24

| | |
|---|---|
| 9:00 a. m. | Registration |
| 9:30 a. m. | Two Technical Sessions: (a) Protective Devices (Symposium on Transmission Line Relays); (b) Transportation |
| 12:30 p. m. | Section and Branch Delegates' Luncheon |
| 2:00 p. m. | Conference of Officers, Delegates, and Members—continued<br>Trips as scheduled<br>Sports as scheduled—First Round for Mershon Trophy<br>Ladies' trip across Harbor to Luncheon and Bridge at Royal Canadian Yacht Club |
| 4:30 p. m. | Afternoon Tea at Royal Canadian Yacht Club |
| 7:00 p. m. | Get-Together Dinner and Entertainment |

Wednesday, June 25

| | |
|---|---|
| 9:30 a. m. | Three Technical Sessions: (c) Automatic Stations; (d) Selected Subjects and Technical Committee Reports; (e) Transmission |

12:30 p. m. Directors' Luncheon and Meeting
Ladies' Drive to Old Mill for Luncheon, to be followed by Golf on miniature course, or Bridge
2:00 p. m. Trips as scheduled
Sports as scheduled—Second Round for Mershon Trophy
4:30 p. m. Afternoon Tea
7:00 p. m. Convenient Banquet
8:15 p. m. Medal Presentation
9:30 p. m. Dancing—Cards

THURSDAY, JUNE 26

9:00 a. m. Boat leaves for trip to new Welland Canal
Lunch at St. Catharines
2:00 p. m. Inspection of Welland Canal
Trips to Queenston and Niagara Falls
Finals—Golf and Tennis
9:00 p. m. Dancing on boat

FRIDAY, JUNE 27

9:30 a. m. Two Technical Sessions: (f) Electrical Machinery and Transmission (Symposium on Coordination of Line, Station, and Apparatus Insulation); (g) Communication
12:30 p. m. Luncheon—Presentation of Prizes
2:00 p. m. Technical Session: (h) Electrical Machinery and Power Generation
4:30 p. m. Afternoon Tea

## LADIES' PROGRAM

The ladies are invited to all events, the following being listed as of special interest to them.

MONDAY, JUNE 23

2:00 p. m. Drive about city followed by afternoon tea at Granite Club
9:00 p. m. President's Reception—dancing

TUESDAY, JUNE 24

2:00 p. m. Trip across Harbor to Luncheon and Bridge at Royal Canadian Yacht Club
7:00 p. m. Get-Together Dinner and Entertainment

WEDNESDAY, JUNE 25

12:30 p. m. Drive to Old Mill for Luncheon, to be followed by Golf on miniature course, or Bridge
7:00 p. m. Convention Banquet
8:15 p. m. Medal presentation
9:30 p. m. Dancing—cards

THURSDAY, JUNE 26

9:00 a. m. Boat leaves for trip to new Welland Canal
Lunch at St. Catharines
2:00 p. m. Drive to Niagara Falls
9:00 p. m. Dancing on boat

FRIDAY, JUNE 27

12:30 p. m. Luncheon—Presentation of Prizes
4:30 p. m. Afternoon Tea

Other entertainment will be announced at the Convention.

## TENTATIVE TECHNICAL PROGRAM

**(Eastern Daylight Saving Time)**

TUESDAY, JUNE 24

9:30 a. m. Parallel Sessions A and B

### A. Protective Devices—Symposium on Transmission Line Relays III

*The Problem of Service Security in Large Transmission Systems*, Paul Ackerman, Consulting Electrical Engineer

*Transmission System—Relay Protection, No. III*, W. W. Edson, The Edison Electric Illuminating Company of Boston

*Modern Requirements for Protective Relays on Important System Interconnections*, O. C. Traver and L. F. Kennedy, General Electric Co.

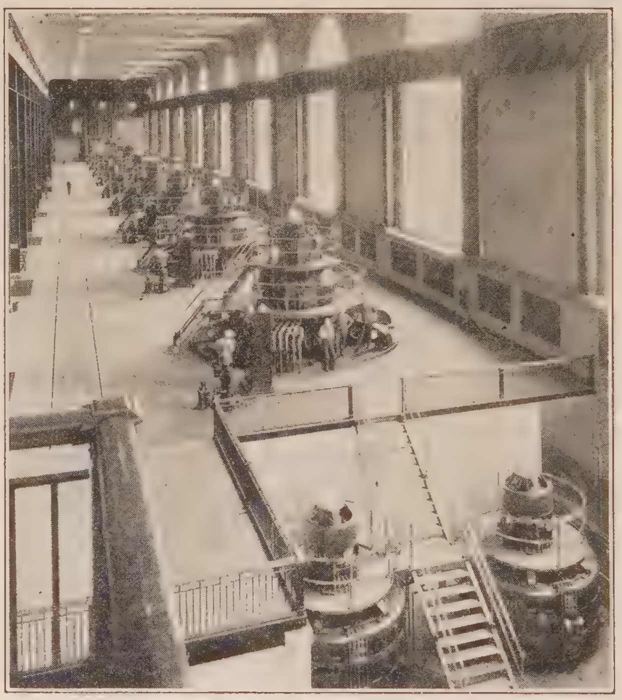
*Directional Ground Relays*, E. E. George and R. H. Bennett, Tennessee Electric Power Co.

*High-Speed Protective Relays*, L. N. Crichton, Westinghouse Electric & Mfg. Co.

### B. Transportation

*Electric Power Consumption for Yard Switching*, P. H. Hatch, N. Y., N. H. & H. R. R. Co.

*Control Systems for Oil and Gasoline Electric Locomotives and Cars*, N. L. Freeman, Westinghouse Electric & Mfg. Co.



QUEENSTON POWER HOUSE, HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO

*Electric Transmission and Control of Power from Internal Combustion Engines for Transportation*, S. T. Dodd, General Electric Co.

*Auxiliaries for High-Voltage D-C. Multiple Unit Cars*, C. J. Axtel, General Electric Co.

*Auxiliary Circuits for High-Voltage D-C. Motor Car Equipments*, O. K. Marti and W. A. Giger, American Brown Boveri Co., Inc.

*Railbonding Practise and Experience on Electrified Steam Railroads*, H. F. Brown, N. Y., N. H. & H. R. R. Co.

WEDNESDAY, JUNE 25

9:30 a. m. Parallel Sessions C, D, and E

### C. Automatic Stations

*An Electron Tube Telemetering System*, A. S. FitzGerald, General Electric Co.

*Development of a Two-Wire Supervisory Control System with Remote Metering*, R. J. Wensley and W. M. Donovan, Westinghouse Electric & Mfg. Co.

*Centralized Control of System Operation*, J. T. Lawson, Public Service Electric & Gas Co.

*Automatic Power Supply of the Carnegie Steel Company*, Robert J. Harry, Eliance Machine Co.

*1000-Kw. Automatic Mercury Arc Rectifier of the Union Railway Company*, New York, W. E. Gutzwiller and Otto Naef, American Brown Boveri Co.

*Miniature Switchboards*, Philip Sporn, American Gas & Electric Co.

**D. Selected Subjects and Technical Committee Reports**

*Rural Line Construction in Ontario*, R. E. Jones, Hydroelectric Power Commission of Ontario

*Mutual Impedances of Ground-Return Circuits—Some Experimental Studies*, H. E. Bowen, American Telephone & Telegraph Co., and C. L. Gilkeson, National Electric Light Association

*Theory and Characteristics of Grid-Controlled Glow and Arc Discharge Tubes*, D. D. Knowles and S. P. Sashoff, Westinghouse Electric & Mfg. Co.

*Effects of the Magnetic Field on Lichtenberg Figures*, C. E. Magnusson, University of Washington

*A Survey of Room Noise in Telephone Locations*, W. J. Williams, National Electric Light Association, and R. G. McCurdy, American Telephone & Telegraph Co.

Reports of Technical Committees reviewing the advances in theory and practise throughout the year in various fields of the electrical industry are listed as follows. These reports will not be presented, but copies will be available and they may be discussed during this session.

| | |
|---|---|
| Automatic Stations | F. Zogbaum, *Chairman* |
| Communication | G. A. Kositzky, *Chairman* |
| Electrical Machinery | P. L. Alger, *Chairman* |
| Electric Welding | A. M. Candy, *Chairman* |
| Electrochemistry and Electrometallurgy | P. H. Brace, *Chairman* |
| Electrophysics | O. E. Buckley, *Chairman* |
| General Power Applications | J. F. Gaskill, *Chairman* |
| Instruments and Measurements | E. S. Lee, *Chairman* |
| Applications to Iron and Steel Production | M. M. Fowler, *Chairman* |
| Production and Application of Light | G. S. Merrill, *Chairman* |
| Applications to Marine Work | W. E. Thau, *Chairman* |
| Applications to Mining Work | Carl Lee, *Chairman* |
| Power Generation | F. A. Allner, *Chairman* |
| Power Transmission and Distribution | H. R. Woodrow, *Chairman* |
| Protective Devices | E. A. Hester, *Chairman* |
| Transportation | Sidney Withington, *Chairman* |

**E. Transmission**

*The 220,000-Volt System of the Hydro-Electric Power Commission of Ontario*, E. T. J. Brandon, Hydro-Electric Power Commission of Ontario

*The Analytics of Transmission Calculations*, T. R. Rosebrugh, University of Toronto

*Study of the Effect of Short Lengths of Cable on Traveling Waves*, K. B. McEachron, General Electric Co.; J. G. Hemstreet, Consumers Power Co. and H. P. Seelye, Detroit Edison Co.

*Buried Distribution Type Transformers*, C. E. Schwenger, Toronto Hydro-Electric System

*Dancing Conductors*, A. E. Davison, Hydro-Electric Power Commission of Ontario

Friday, June 27

9:30 a. m. Parallel Sessions F and G

**F. Electrical Machinery and Transmission–Symposium on Coordination of Line, Station, and Apparatus Insulation**

*Rationalization of Station Insulating Structures with Respect to Insulation of Transmission Lines*, C. L. Fortescue, Westinghouse Electric & Mfg. Co.

*The Effect of Transient Voltages on Dielectrics—IV; Law of Impulse Sparkover and Time Lag*, F. W. Peek, Jr., General Electric Co.

*Rationalization of Transmission Line Insulation Strength—II*, Philip Sporn, American Gas and Electric Co.

*Recommendations on Balancing Transformer and Line Insulation on Basis of Impulse Voltage Strength*, V. M. Montsinger, General Electric Co., and W. M. Dann, Westinghouse Electric & Mfg. Co.

*Coordination of Insulation as a Design Problem*, G. D. Floyd, Hydro-Electric Power Commission of Ontario

*Standards of Insulation and Protection for Transformers*, J. A. Johnson, Buffalo, Niagara and Eastern Power Corp., and E. S. Bundy, Niagara, Lockport & Ontario Power Co.

*Essential Factors in the Coordination of Line, Station, and Apparatus Insulation*, A. E. Silver and H. L. Melvin, Electric Bond and Share Co.

Leaside, 25,000-Kv-A. Outdoor Condensers

**G. Communication**

*Long Distance Cable Circuit for Program Transmission*, A. B. Clark, American Telephone & Telegraph Co., and C. W. Green, Bell Telephone Laboratories, Inc.

*Transmission Characteristics of Open Wire Telephone Lines*, E. I. Green, American Telephone & Telegraph Co.

*Study of Telephone Line Insulators*, L. T. Wilson, American Telephone & Telegraph Co.

*General Switching Plan for Telephone Toll Service*, H. S. Osborne, American Telephone & Telegraph Co.

*Long Telephone Lines in Canada*, J. L. Clarke, Bell Telephone Company of Canada

*Two-Way Television*, H. E. Ives, Bell Telephone Laboratories, Inc.

2:00 p. m. Session H

**H. Electrical Machinery and Power Generation**

*Effects of Lightning Voltages on Rotating Machines and Methods of Protecting Against Them*, F. D. Fielder and E. Beck, Westinghouse Electric & Mfg. Co.

*Effect of Voltage Surges on Rotating Machinery*, E. W. Boehne, General Electric Co.

*Vertical Shaft 25,000 Kv-a. Synchronous Condensers*, H. A. Ricker, J. R. Dunbar and R. E. Day, Canadian Westinghouse Co.

*Metal-Clad, Gum-Filled Switching Equipment*, L. B. Chubbuck, Canadian Westinghouse Co.

*East River Generating Station of the New York Edison Company,* C. B. Grady, W. H. Lawrence, and R. H. Tapscott, New York Edison Co.

*Present Day Hydro Power Practise in Central Europe,* A. V. Karpov, Aluminum Company of America

## Trips

### Welland Canal

The outstanding trip will be an all-day outing, crossing Lake Ontario to visit the new Welland Canal, which embraces some features excelling anything hitherto undertaken in canal construction. Those desiring to do so will be able to spend the afternoon at the Queenston Plant of the Hydro-Electric Power Commission or at various power plants at Niagara Falls. Special entertainment features are being arranged in connection with this trip, in a way that will insure a day of general relaxation and enjoyment.

### Leaside Station

The Leaside Station of the Hydro-Electric Power Commission on the outskirts of Toronto is Canada's first 220-kv. receiving station. It has many interesting features, including two 25,000-kv-a. outdoor synchronous condensers.

### Other Power Stations

H. E. P. C.—Bridgeman—110-kv. Station.
Wiltshire—110-kv. Station.
Strachan Ave.—110-kv. Station and Laboratories.
Toronto Hydro-Electric System
Automatic High Power Mercury Arc Rectifier Railway Station.
Supervisory Control Substations.
Local Dispatching Office in Duncan Street Station.

### Electric Manufacturing Plants

Davenport Works—Canadian General Electric Co.
Hamilton Works—Canadian Westinghouse Co.
Mount Dennis Plant—Ferranti Electric Limited.

### Points of Interest

Hillcrest Shops—Toronto Transportation Commission.
Toronto Harbor Development.
University of Toronto Buildings.
Royal Ontario Museum.

There are also many manufacturing plants to which trips will be arranged as desired.

## Sports

### Golf

The main event for golfers will be the annual tournament for Mershon Trophy, which will be played over the course of the Weston Golf and Country Club.

As it is proposed to present the prizes at the luncheon on Friday, and as the match play in this competition will consume all other available time, it is essential that the qualifying round be completed on Monday. This will mean that guests arriving after Monday will be unable to enter the Mershon Cup competition.

> The competition will consist of a qualification round (handicap medal play) of eighteen holes, followed by match play (handicap).
>
> The sixteen low net scores will qualify for the match play rounds, which will be played on Tuesday p. m., Wednesday p. m., and Thursday, a. m. and p. m.
>
> Arrangements will be made by the Committee so that officers, section delegates, et al., may play their qualification rounds at any particular time on Monday, so as to avoid missing their scheduled meetings.

The Committee are also arranging other events of which the details will be given out at registration. These events will not be confined to the course of the Weston Golf & Country Club, as arrangements are being made to allow members and registered guests to play over a number of courses in the Toronto vicinity; in these competitions, all scores will count.

It is hoped that chief among these additional events will be an International Team Competition for the American-Canadian Team championship of the Institute, arrangements for which are now being worked out.

No greens fees will be charged members or registered guests for any play during the Convention, and transportation to and from all courses will be provided.

### Tennis

The annual Mershon Trophy competition in men's singles will be played, together with men's doubles, and, if sufficient entries can be secured, ladies' singles and mixed doubles will also be arranged.

The courts on which these events will be played will be announced later, but tennis players may feel assured that excellent courts (probably clay) will be available for all who wish to use them.

Entries for all these events should be in the hands of the Committee not later than Monday afternoon.

SCENE ON WESTON GOLF COURSE

## Entertainment

The principal entertainment features are shown in the foregoing program. It is expected that of their respective kinds, these events will be outstanding. In general, the Committee is leaving no stone unturned in its efforts to make this Convention a memorable one.

### Ladies

The ladies attending the Convention should have a particularly interesting time, as the Committee has arranged a most attractive program for their entertainment. In addition to the all-day trip by boat across Lake Ontario to view the Welland Canal, there will be two different drives covering points of interest in and about the city. An afternoon of golf has been arranged, preceded by luncheon, and there will be bridge arranged for those not playing golf.

On another afternoon it has been planned to take the ladies for launch rides along the lake shore in the vicinity of the harbor, and have tea served at the Royal Canadian Yacht Club. There will be two evenings of dancing during the Convention.

A large local Committee of Ladies will do everything possible for the comfort and pleasure of visiting ladies, individually and collectively.

## Hotels

The Royal York Hotel, which will constitute Convention Headquarters, has been operating just about one year. It compares favorably not only in all general particulars with the latest and best of new hotels anywhere, but has a whole floor devoted to special convention rooms. It is in direct communica-

tion with the Union Station and overlooks the Harbor and Lake Ontario.

Following is a list of hotels, their rates, and distances from the headquarters hotel. *Reservations should be made by communicating directly with the manager of the hotel selected:*

| Hotels | Single room running water | Single room with bath | Double room without bath | Double room with bath | Distance from headquarters |
|---|---|---|---|---|---|
| Royal York.... | .. | \$4–\$8 | .. | \$8–\$9–\$10 | Headquarters |
| King Edward.. | .. | \$3.50–\$8 | .. | \$6–\$12 | ½ mile |
| Prince George.. | .. | .. | \$5–\$7 | \$7–\$10 | 3 blocks |
| Walker House.. | \$4–\$5 | .. | .. | .. | across street |
| Carls-Rite...... | \$4–\$5 | .. | .. | .. | 1 block |
| Hotel Waverly. | \$2–\$3 | \$3–\$4 | \$4–\$5 | \$5–\$8 | 1 mile |
| Westminster ... | .. | \$3 | .. | \$6 | 1 mile |
| Ford Hotel..... | \$1.50 | \$2–\$2.50 | \$2.50 | \$3–\$4.50 | ¾ mile |

**Railroad Rates**

It has been ascertained that in nearly all cases the Summer Tourist rates are lower than those offered by the Convention Certificate plan. On this account certificate rates are not being arranged and members are advised to procure Summer Tourist tickets.

**Committees**

The 1930 Summer Convention Committee which is making arrangements for the Convention consists of the following members who are officers of the General Convention Committee or chairmen of other committees as indicated, or general members: C. E. Sisson, Chairman; A. H. Hull, Vice-Chairman; W. L. Amos, Secretary; A. E. Knowlton, Meetings and Papers; W. P. Dobson, Local Representative, Meetings and Papers; W. B. Kouwenhoven, Sections; W. A. Bucke, Finance; H. U. Hart, Finance; F. R. Ewart, Publicity; A. B. Cooper, Entertainment; H. C. Don Carlos, Sports; J. F. Neild, Transportation; M. B. Hastings, Trips; F. F. Ambuhl, Hotel and Registration; H. C. Barber, Ladies; W. C. Adams, C. V. Christie, J. L. Clarke, J. R. Cowley, E. P. Fetherstonhaugh; J. A. Johnston, H. Milliken, J. Morse, W. F. McKnight, J. Teasdale and J. B. Woodyatt.

## The 1930 Lamme Medal

**NOMINATIONS FOR THE 1930 AWARD WILL BE RECEIVED UNTIL OCTOBER 1**

As a result of a bequest of the late Benjamin G. Lamme, Chief Engineer of the Westinghouse Electric & Mfg. Company, who died July 8, 1924, the Lamme Medal was founded to provide for the award by the Institute of a gold medal (together with bronze replica thereof) annually to a member of the A. I. E. E. "who has shown meritorious achievement in the development of electrical apparatus or machinery," and for the award of two such medals in some years if the accumulation from the funds warrants.

The second (1929) Lamme Medal has been awarded to Rudolf Emil Hellmund, Chief Electrical Engineer, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., "for his contributions to the design and development of rotating electrical machinery," and will be presented during the Summer Convention of the A. I. E. E. at Toronto, Ont., Canada, June 23-27.

Special attention is called to the fact that names of members of the Institute, who are considered suitable candidates for the Lamme Medal to be awarded in the Fall of 1930, may be submitted by any member in accordance with Section 1 of Article VI of the By-laws of the Lamme Medal Committee, which is quoted below:

"The Committee shall cause to be published in one or more issues of the A. I. E. E. Journal each year, preferably including the June issue, a statement regarding the 'Lamme Medal' and an invitation for any member to present to the National Secretary of the Institute by October 1 the name of a member as a candidate for the Medal, accompanied by a statement of his 'meritorious achievement' and the names of at least three engineers of standing who are familiar with the achievement."

Each nomination should give concisely the specific grounds upon which the award is proposed, and also a complete detailed statement of the achievement of the nominee, so as to enable the Committee to determine its significance, comparing each with those of other candidates. If the work of the nominee has been of a somewhat general character in cooperation with others, specific information should be given regarding the contributions of the individual. Names of endorsers should be given as specified above.

## Pacific Coast Convention, Portland, Oregon September 2-5

Well advanced plans for an instructive and entertaining Pacific Coast Convention at Portland, Oregon, September 2-5, 1930, are announced by H. H. Schoolfield, Chairman of the General Convention Committee, functioning for the past five months. Five technical sessions, two Student Branch sessions and a Conference on Student Activities by the Counselors' Committee from Districts 8 and 9 are scheduled on the business program, while ample provision is being made for recreation and entertainment. Convention headquarters will be the Multnomah Hotel and all business sessions will be held there.

### Technical Sessions

A wealth of material from which to choose papers for discussion in the technical sessions has been unearthed by the Program Committee in charge of H. H. Cake. These discussions, which will range from the extremely practical to the more theoretical realm of pure research, fall into four general classifications: Transmission and distribution; Power station development; Communication; and Research. A few of the specific subjects of some of the papers already signed up are forecasting precipitation, mercury arc rectifiers, corona tests, porcelain insulator research, and power company communication systems.

### Entertainment, Trips and Sports

An informal reception and dance, the annual golf tournament for the J. B. Fisken cup, followed by an informal banquet at the Country Club, are the major features of the entertainment program being arranged by C. W. Fick, Chairman of the Entertainment Committee, and R. J. Cobban, Golf Committee Chairman. Plans are being made to secure for the golf tournament, the course of the Portland Golf Club,—one of the finest among Portland's many excellent courses, while the ample facilities afforded by the new club house at that course will make an excellent setting for an informal banquet and dance the evening of the tournament.

In charge of E. F. Pearson, a number of trips of diverse interest are being planned; among them, a trip to the Oak Grove Development of the Pacific Northwest Public Service Company on the Clackamas River, (where a second generating unit is being installed), and a trip to the Northwestern Electric Company's hydroelectric development on the Lewis River, (where dam construction will be in full swing), are expected to offer considerable appeal.

Entertainment for the ladies will be in charge of Mrs. A. S. Moody, who is making plans that will keep the visiting wives agreeably occupied at luncheons, teas, and bridge at a number of the many beauty spots in and around Portland.

### Program Arrangement

The tentative arrangement of technical sessions and other features is as follows:

Members are urged to plan their vacations to include this Convention. The north west is rapidly becoming a very popular summer playground, and Portland, situated in the center of this

playground area, is a convenient starting point from which to travel to the many points of interest in the territory.

Convention Subcommittees

The following have been selected from the General Convention Committee to handle the various activities in connection with the Convention: Program, H. H. Cake; Golf, R. J. Cobban; Entertainment, C. W. Fick; Finance, A. S. Moody; Hotel, A. K. Morehouse; Transportation, C. P. Osborne; Publicity, Berkeley Snow; Reception, J. E. Yates; Registration, A. H. Kreul; Trips, E. F. Pearson; Ladies Entertainment, Mrs. A. S. Moody.

## STANDARDS

### Revision of Federal Lamp Specifications

A proposed revision of the Federal Specifications for Lamps (Electric, Incandescent, Miniature and large Tungsten Filament) 23c and 618 and their 1931 supplements is now being circulated for comment and criticism. Those interested may obtain copies by applying directly to the Federal Specifications Board, Dept. of Commerce, Washington, D. C.

### Air Circuit Breaker Standards

At the May 9th meeting of the Standards Committee, the Report on Air Circuit Breakers, No. 20, was recommended for approval and publication as an A. I. E. E. Standard. The report has been available in pamphlet form since June 1928. The final Standard will be identical with the printed report with the exception of the addition of five definitions as follows: High Speed Breaker; Trip-Free-Electrically and Mechanically; Interrupting Rating; Standard Operating Duty; Interrupting Performance.

### Constant Current Transformer Standards

The Report on Standards for Constant Current Transformers, available in printed form since June 1929, was recommended for approval and publication as an A. I. E. E. Standard at the meeting of the Standards Committee of May 9. The final Standard will include certain revisions of the material contained in the report. These revisions are the result of suggestions received since the general circulation of the report.

### Revision of Automatic Station Standards

The Committee on Automatic Stations reported to the Standards Committee on May 9th recommending the revision of Standard No. 26, Automatic Stations. The revisions consist in certain changes in functional numbers used to designate apparatus, and also changes in the table showing requirements for minimum protection of power apparatus. The Standards Committee voted the approval of the revisions for inclusion in the next reprinting of the Standard.

### Report on Standards for Capacitors

The Electrical Machinery Committee submitted for the approval of the Standards Committee at the May 9th Meeting, a report on Standards for Capacitors. This report was approved by the Standards Committee and will shortly be available in pamphlet form for criticism and suggestion.

### Revision of Transformer Standards

An extensive revision of the Standards for Transformers, Induction Regulators and Reactors, No. 13; was approved by the Standards Committee at the meeting of May 9th. The revised Standard will be available shortly as a new edition of No. 13.

### Insulated Wires and Cables

The Sectional Committee on Insulated Wires and Cables has prepared three new specifications, as follows: Specifications for Weatherproof (Weather Resisting) Wires and Cables; Specifications for Heat-Resisting Wires and Cables; Specifications for Code Rubber Insulation for Wire and Cable for General Purposes. These specifications are available for comment. Address Francis J. White, Secretary Sectional Committee on Insulated Wires and Cables, c/o Okonite Co., 501 Fifth Ave., New York, N. Y.

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## Northeastern District Holds Fine Meeting in Springfield

An enjoyable and instructive meeting was held under the auspices of the North Eastern District of the A. I. E. E. at the Hotel Kimball, Springfield, Mass., May 7-10, inclusive. The technical sessions and social functions were attended by 350 members and their guests.

A session on Student Activities, a Luncheon Conference of Counselors, Branch Delegates, and a Student Technical Session were held on Friday, with an attendance of 125 students. A complete account of these Student sessions is given in the Student Activities department of this Journal.

The Banquet

The convention banquet was highly enjoyed and well attended by the members and their guests.

E. B. Merriam, Chairman of the General Committee, and Vice-President of the North Eastern District, A. I. E. E., was toastmaster. After dinner was served, he introduced the speaker of the evening, Captain Abernethy, who vividly described his experiences in the Aviation Corps during the War, as well as the experiences of a number of eminent fliers in the Allied and German Air Forces.

Professor Karapetoff gave a musical demonstration on the theremin, accompanied at the piano by Mrs. F. L. Hunt. The Professor briefly but precisely described the principle of operation of the electrical musical instrument and demonstrated how the pitch and volume were controlled by moving the hands closer or farther away from the terminal antennas, thus changing the capacitance of the circuits and producing different sounds. Several selections were then rendered.

Mr. A. C. Stevens announced the awards of the District First Prize, District Prize for Initial Paper, and District Prize for Branch Paper. The names of the winners and the titles of their papers are given in the following columns of this issue.

Mr. J. P. McKearin of the Sports Committee announced and presented prizes to the winners of the Golf and Tennis Tournaments.

At the conclusion of the banquet, dancing was enjoyed by a number of members and their guests.

Inspection Trips

Many interesting and instructive inspection trips to points of historical, industrial, and constructional interest, in and about Springfield, were greatly enjoyed by those attending the meeting. Among the places visited were the U. S. Arsenal and Museum, automatic substations of the United Electric Light Company, the East Springfield Works of the Westinghouse Electric & Manufacturing Company, the Fisk Rubber Company, the Woronoco Mills of the Strathmore Paper Company, the plant of the American Bosch Magneto Corporation, and the mercury turbine installation of the Hartford Electric Company at Hartford. Saturday, a group attending the meeting enjoyed an all-day outing and trip to the Cobble Mountain hydroelectric and City of Springfield water supply development. Basket luncheons for those taking the trip were provided by the committee.

During the hours of the technical sessions, the ladies were entertained with auto drives to a number of points of interest in Springfield and surrounding country. Amherst Agricultural College, Bigelow-Hartford Carpet Plant, and The Harris Hosiery Company were visited by the ladies. Other entertainment

consisted of luncheons, dancing and cards. On Friday evening, a theater party was enjoyed by many of the ladies and members.

### Sports—Golf and Tennis

About fifty members participated in the golf tournament which was played over the 18-hole course of the Springfield Country Club. The first prize, a golf club bag, was won by John T. Binford with a gross score of 88. Second prize, a Gladstone, was taken by G. O. Bason with a gross score of 99. H. T. Malmberg won the third prize, a leather traveling bag with a gross score of 106. A total of fifteen prizes consisting of a variety of leather goods, traveling kits and other novelties was awarded by the sports committee.

First and second prizes for tennis consisted of tennis racquets won by C. T. Walker and L. B. Harvey, respectively.

## Wednesday, May 7

The first session of the North Eastern District Meeting, was opened at 9:00 a. m. by F. L. Hunt, Chairman of the Springfield Section. Mr. Hunt introduced Dwight R. Winter, Mayor of Springfield, who, in behalf of the citizens and manufacturing industries of the City of Springfield, welcomed the convention.

E. B. Merrian, Vice-President, North Eastern District, A. I. E. E., gave a brief address, humorously, but appropriately, referring to the different types of discussors. He then turned the meeting over to E. S. Lee, Chairman of the Committee on Instruments and Measurements.

### Instruments and Measurements Session

Chairman E. S. Lee, after outlining the conduct of the session, called on C. M. Hathaway for the presentation of the first paper. Mr. Hathaway described a new portable oscillograph recently developed, having the advantages of compactness, portability for use in lecture room work, or to obtain photographic records by removing the ground glass and inserting a small camera.

Mr. I. F. Kinnard presented a paper entitled *A Self-Compensating Temperature Indicator.* A part of the paper described the properties of an alloy called "calmaloy" and its use in connection with the compensation of the d'Arsonval instrument. Mr. Ketchum outlined a means of determining generator speed and retardation during loss measurements. The last paper in the Instruments and Measurements session entitled *Phase Defect Angle of Air Capacitor* was admirably presented by Professor W. B. Kouwenhoven. Professor Kouwenhoven described the capacitor and the scope of the tests.

Mr. Hazen described the M. I. T. network analyzer, pointing out its fields of usefulness and also stating the types of problems on which the analyzer could not be used.

### Transmission Session

The afternoon session on Transmission was called to order bd W. H. Colburn acting chairman, in the absence of E. W. Dillary due to illness. Mr. Colburn pointed out that the five papers to be presented might well be divided into two groups, one group dealing with the subjects of a theoretical nature, the other group treating the constructional and design features of transmission. The chairman called upon F. E. Andrews to present the first paper entitled *Transmission Research and Design with the Field as a Laboratory.* Statistics were recorded from observations in the field, and line construction was altered or changed to remedy conditions and minimize outages on transmission lines. Professor H. B. Dwight admirably presented the second paper of the session entitled *Calculation of Protection of a Transmission Line by Ground Conductors.* Mr. P. H. Thomas explained the advantages of a new type of transmission line construction using post type towers hinged at the top to the cross members, and at the footings, permitting the construction of a line closer to the ground, which is less hazardous with lightning, and possessing compensating interruption flexibility features. Mr. J. E. Clem described the effect of using a neutral impedance in connection with arcing grounds. H. A. Frey outlined the operating experience of various power companies using fused grading shields.

## Thursday, May 8

### Electrical Machinery

Mr. J. A. Johnson, Chairman of the first Electrical Machinery session, called the meeting to order at 9:00 a. m. The manner in which the session would be conducted was briefly outlined, Mr. Johnson then calling for the presentation of the first paper. K. K. Palueff presented a paper entitled *Effect of Transient Voltage on Power Transformer Design—The Behavior of Transformers with Neutral Isolated or Grounded through an Impedance.* Some of the salient features of the paper were illustrated with the aid of lantern slides and diagrams. Mr. J. M. Lyons ably explained methods of reducing eddy-current losses by inverted turn transposition and twisted lead transposition. The third paper of the session entitled *Effect of Armature Resistance upon Hunting of Synchronous Machines* was presented by C. F. Wagner. Mr. F. R. Longley presented the last paper in the session, outlining the calculation of alternator swing curves and stating the fundamental principles upon which the paper was based. The author also acknowledged the work of Mr. Summers and others who had rendered valuable assistance in connection with the preparation of this paper.

### Electrical Machinery, Second Session

At 1:30 p. m. Professor H. B. Dwight, Chairman of the second Electrical Machinery session, called on H. C. Specht for the presentation of the first paper in that session. Mr. Specht read his paper describing the synchronous repulsion motor, specially developed for the speed requirements of photophone service. The second paper to be presented was entitled *The Synchronous Motor Defects in Induction Machines.* Mr. E. E. Dreese mentioned the general principles and called attention to the chronological summary. Professor H. B. Dwight, chairman, commented on the importance of Mr. Dreese's paper. C. G. Veinott presented the third paper on the subject of *Transformer Ratio and Differential Leakage of Distributed Windings.* The fourth paper of the session, written by P. L. Alger and entitled *Induction Motor Performance Calculations,* was presented in the absence of Mr. Alger, (who is at present in Europe) by Mr. C. J. Koch. This paper described an exact equivalent method of calculation of induction motor performance. The last paper in this session entitled *Voltage Irregularities in D-C. Generators,* was presented by J. T. Fetsch, Jr. of the Naval Research Laboratory. Mr. Fetsch, with the aid of lantern slides, clearly illustrated commutator ripple and slot ripple.

## Friday, May 9

### Selected Subjects

Mr. J. P. McKearin, Acting Chairman for Mr. F. L. Hunt, called the session on Selected Subjects to order at 9:00 a. m. Professor K. L. Wildes presented the first paper on the subject of *Cooperative Courses,* explaining their development and operating principles. Mr. H. L. Rorden presented a paper entitled *Shunt Resistors for Reactors,* explaining the elimination of building up higher potentials by incoming waves on terminal apparatus by shunting reactors with the proper value resistors. Mr. L. Espenschied interestingly described *Radio Telephone Service to Ships at Sea,* explaining and illustrating with curves how the shorter wavelengths provided the facilities for the use of higher frequencies, which increased communication distances during the daytime. Presentation was aided by the use of lantern slides, illustrating the stations and apparatus. Mr. W. B. Kirke outlined *Methods for the Calculation of Cable Temperature in Subway Ducts.* He pointed out that many variables, such as geometric factors, structure of the duct band, cyclic globes, number of cables in the duct band, etc., all have to be considered in the calculations. The last paper in the session on Selected Subjects entitled *Relations of D-C. and A-C. High- and Low-Voltage Measurements on Rubber Cable* was presented by Mr. C. L. Kasson. By the use of lantern slides Mr. Kasson illustrated with curves that the order of merit

of five different pieces of rubber insulated cables, subjected to d-c. stresses and subjected to a-c. stresses, are the same. This paper brought forth considerable comment during the discussion which followed.

In spite of the extreme heat of the weather, the technical sessions were very well attended. Real live and constructive discussion followed the presentation of several of the papers. A complete record of each discussor's remarks will be incorporated in the TRANSACTIONS of the Institute.

## A. I. E. E. Directors Meeting

The regular meeting of the Board of Directors of the American Institute of Electrical Engineers was held at Institute headquarters, New York, on Friday, May 23, 1930.

There were present: President Harold B. Smith, Worcester, Mass.—Vice-Presidents E. B. Merriam, Philadelphia, Pa.; H. A. Kidder, New York, N. Y.; W. T. Ryan, Minneapolis, Minn.; W. S. Rodman, University, Va.; C. E. Sisson, Toronto, Ont.—Directors H. C. Don Carlos, Toronto, Ont.; F. C. Hanker, East Pittsburgh, Pa.; E. B. Meyer, Newark, N. J.; J. Allen Johnson, Buffalo, N. Y.; A. M. MacCutcheon, Cleveland, Ohio; J. E. Kearns, Chicago, Ill.; C. E. Stephens, New York, N. Y.—National Secretary F. L. Hutchinson, New York, N. Y.

The minutes of the Directors' meeting of March 14, 1930, were approved.

Reports of meetings of the Board of Examiners held March 26, April 23, and May 21, were presented; and upon the recommendation of the Board of Examiners, the following actions were taken upon pending applications: 134 Students were enrolled; 231 applicants were elected to the grade of Associate; 22 applicants were elected to the grade of Member; one applicant was elected to the grade of Fellow; 31 applicants were transferred to the grade of Member; six applicants were transferred to the grade of Fellow.

The Board ratified the approval by the Finance Committee, for payment, of monthly bills amounting to $27,009.69. The Finance Committee reported the annual audit of the Institute's accounts by Haskins & Sells, whose statement is included in the annual report of the Board of Directors.

The annual report of the Board of Directors to the membership, for the fiscal year ending April 30, 1930, as prepared under the direction of the National Secretary, was considered and approved for presentation at the Annual Meeting, on June 23.

The annual report of the National Treasurer for the fiscal year ending April 30, 1930, was received.

The annual reports of the general standing committees (exclusive of the reports of the technical committees, which are presented at the Annual Summer Convention in June) were received, abstracts of which were incorporated in the Board of Directors' annual report.

The National Secretary reported 1292 members in arrears for dues for the year ending April 30, 1930, and was directed to transfer these members from the mailing list to a "suspended" list, and to employ the usual methods of collecting the dues and restoring the members to the active membership list.

In accordance with Sec. 37 of the Constitution, the appointment of a National Secretary for the administrative year beginning August 1, 1930, was considered, and National Secretary F. L. Hutchinson was reappointed.

Approval was given to the dates, May 6-10, 1931, of the previously authorized North Eastern District meeting to be held in Rochester, N. Y., and authorization was given to the South West District to hold a meeting in Kansas City, Mo., in October 1931. Asheville, N. C., was approved as the location of the Annual Summer Convention to be held the last week in June, 1931.

Authorization was given for the organization of two new Sections, one at Memphis, Tenn., and the other at San Antonio, Tex. A request from the Dallas Section for an extension of territory was also granted.

On the ground that in order to serve all of its members it is not advisable for the Institute to relinquish entirely any activity which is also being carried on by some other organization, the following resolution was adopted, upon the recommendation of the Committee on Coordination of Institute Activities:

Each Technical Committee shall cooperate with similar committees of other organizations so that all concerned may be kept informed of related activities. Such cooperation, however, shall not be permitted to limit the scope of Institute activities within the field of electrical engineering. No activity within the field of electrical engineering shall be relinquished for any reason if such activity is desirable in order that the Institute may completely serve all of its members. In case of doubt as to the proper scope of Institute activities, a ruling should be secured from the Board of Directors.

The report of the Committee on Award of Institute Prizes, of prizes awarded for the year 1929, was presented, and accepted, as appearing elsewhere in this issue.

Upon the recommendation of the Standards Committee, the following actions were taken: (1) A. I. E. E. Standards for Constant Transformers were adopted; (2) A. I. E. E. Standards for Air Circuit Breakers were adopted; (3) a revision of Standard No. 13—Transformers, Induction Regulators and Reactors—was approved; (4) and approval was given to a revision of Standard No. 26—Automatic Stations.

An invitation from the Committee of Award of Popular Science Monthly, to appoint a committee to nominate a candidate each year for the annual award of $10,000 for achievement in science of greatest value to the public, was accepted and the president was authorized to appoint the committee.

Other matters were discussed, reference to which may be found in this and future issues of the JOURNAL.

## Brooklyn Polytechnic to Celebrate 75th Anniversary

On June 17th and 18th Polytechnic Institute of Brooklyn will celebrate the completion of its seventy-fifth year. On the evening of the 17th, an anniversary dinner under the auspices of the Corporation, Faculty, and Alumni will be held at the St. George Hotel in Brooklyn. Among the speakers will be Walter Hampden, Polytechnic 1900; Doctor Frank Graves, Commissioner of Education of the State of New York, and Professor Karl Compton, of Princeton University, President elect of the Massachusetts Institute of Technology.

Commencement will be on June 18th, with Dr. Graves as the speaker. First honorary degrees in the history of the Institute will be conferred on Admiral Richard E. Byrd and Professor Karl Compton.

## Annual Meeting of Special Libraries Association

Members of the Commercial-Technical group of the national Special Libraries Association, composed of the librarians of the leading public utility, transportation, advertising and industrial libraries, are planning an interesting program of activities for the Twenty-Second Annual Convention of that organization, to be held in San Francisco, June 18th to 21st. For the most part the general sessions of the convention will deal with the progress of the West, industrially and culturally, with leading western industrial engineers and civic figures as speakers.

## Purdue University to have History of Engineering Library

By Mrs. Goss, the entire library of the late Doctor W. F. M. Goss has been turned over to Purdue University, together with $20,000, to establish a library there for engineering history.

This should form a valuable nucleus for anyone wishing to donate or sell to the University, books of value to such a history of engineering. It is suggested that information relevant to the subject of such additions be addressed to A. A. Potter, Dean of Engineering, Purdue University, Lafayette, Indiana.

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## National Prizes Awarded for Papers

Four National Prizes for papers presented during 1929 have been awarded by the Committee on Award of Institute Prizes. These prizes consist of suitable certificates and $100 in cash, the cash prize being divided in case of joint authorship. These prizes will be presented to the winners on June 23 at the Summer Convention. The members of the Committee who acted upon these awards were Messrs. A. E. Knowlton, Chairman, H. P. Charlesworth, and W. S. Gorsuch. The substance of the Committee's report is as follows:

National First Prize in the field of Engineering Practise awarded to Messrs. R. C. Dickinson and B. P. Baker for their paper entitled *Structural Development of the Deion Circuit Breaker*, presented at the A. I. E. E. Winter Convention, New York, January 28-February 1, 1929.

Honorable Mention was made of papers by C. M. Laffoon (*Increased Voltages for Synchronous Machines*, presented at the Great Lakes District Meeting, Chicago, Illinois, December 2-4, 1929) and C. F. Hirshfeld (*Rehabilitation and Rebuilding of Steam Power Plants*, presented at the A. I. E. E. Summer Convention, Swampscott, Massachusetts, June 24-28, 1929).

National First Prize in the field of Theory and Research was awarded to K. K. Palueff for his paper entitled *Effect of Transient Voltages on Power Transformer Design*, presented at the A. I. E. E. Winter Convention, New York, January 28-February 1, 1929.

Honorable Mention was made of the paper by D. W. Kitchin entitled *Power Factor and Dielectric Constant in Viscous Liquid Dielectrics*, presented at the A. I. E. E. Winter Convention, New York, January 28-February 1, 1929.

National Prize for Initial Paper is awarded to C. T. Weller for his paper entitled *132-Kv. Shielded Potentiometer for Determining the Accuracy of Potential Transformers*, presented at the A. I. E. E. Winter Convention, New York, January 28-February 1, 1929.

Honorable Mention is to be given to J. A. Noertker for his paper entitled *Street Railway Power Economics*, presented at the A. I. E. E. Middle Eastern District Meeting, Cincinnati, Ohio, March 20-23, 1929.

National Prize for Branch Paper was awarded to Messrs. W. A. Merriam and H. R. Arnold for their paper entitled *Some Factors Affecting the Power Limits of a Transmission System*, presented at the joint meeting of the Denver Section and University of Colorado Branch of the A. I. E. E., April 26, 1929.

Honorable Mention in this instance is given to S. O. Rice for his paper entitled *The Heating of Copper Conductors by Transient Electric Currents*, presented at the A. I. E. E. Pacific Coast Convention, Santa Monica, California, September 3-6, 1929.

No prize was awarded in the field of Public Relations and Education.

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## Districts Award Paper Prizes

Fifteen District Prizes for papers presented during 1929 have been awarded by eight Districts of the Institute. Each of these prizes consists of an appropriate certificate and $25 cash; in case of joint authorship, the cash award being divided. The awards are as shown below:

District No. 1

**District First Prize.** B. L. Robertson and I. A. Terry for their paper *Analytical Determination of Magnetic Fields*, presented at the A. I. E. E. Summer Convention at Swampscott, Mass., June 24-28, 1929.

**District Prize for Initial Paper.** John B. Cox for his paper *Electrification of the Mexican Railway*, presented at the A. I. E. E. Summer Convention at Swampscott, Mass., June 24-28, 1929.

**District Prize for Branch Paper.** Theodore A. Rich for his paper *The Development of a New Type of Indicator for Electrical Measuring Instruments*, presented at the Annual Student Convention of the North Eastern District of the A. I. E. E., May 10-11, 1929.

District No. 2

**District First Prize.** J. A. Noertker for his paper *Street Railway Power Economics on the Cincinnati System*, presented at the A. I. E. E. District Meeting in Cincinnati, Ohio, March 20-23, 1929.

**District Prize for Initial Paper.** H. F. L. J. Seyler for his paper *Current Characteristics of Constant Current Transformers during Sudden Changes of Load*, presented before the Institute's Baltimore Section in 1929.

District No. 3

**District Prize for Branch Paper.** William H. Conron and Frank A. Goss, Jr. for their paper *Voltage Regulation of a Direct-Current Generator by Means of Vacuum Tubes*, presented before a meeting of the New York University Branch on May 10, 1929.

District No. 5

**District Prize for Branch Paper.** John E. Dean for his paper *Determination of the Temperature of Underground Power Cables from Load*, presented at the Great Lakes District Meeting, Chicago, December 2-4, 1929.

District No. 6

**District First Prize.** W. C. DuVall and Mabel Macferran for their paper *Power Limits of the Southern California Edison Company's Big Creek Transmission System*, presented at a meeting of the Denver Section, November 15, 1929.

**District Prize for Branch Paper.** W. A. Merriam and H. R. Arnold for their paper *Some Factors Affecting the Power Limits of a Transmission System*, presented at a joint meeting of the Denver Section and the University of Colorado Branch, April 26, 1929.

District No. 8

**District First Prize.** N. B. Hinson for his paper *Population as an Index to Electrical Development*, presented at the Pacific Coast Convention at Santa Monica, California, September 3-6, 1929.

**District Prize for Initial Paper.** Mabel Macferran for her paper *Parallel Operation of Transformers Whose Ratios of Transformation are Unequal*, presented at the A. I. E. E. Pacific Coast Convention at Santa Monica, California, September 3-6, 1929.

**District Prize for Branch Paper.** H. R. Lubcke for his paper *Design Equations for Vacuum Tube Voltmeters*, presented at the joint meeting of the San Francisco Section, University of California Branch, University of Santa Clara Branch and Stanford University Branch on April 10, 1929.

District No. 9

**District Prize for Branch Paper.** Stephen O. Rice for his paper *The Heating of Copper Conductors by Transient Electric Currents*, presented at the A. I. E. E. Pacific Coast Convention in Santa Monica, California, September 3-6, 1929.

District No. 10

**District First Prize.** Arthur E. Davison for his paper *220-Kv. Transmission Line of the Hydro-Electric Power Commission*, Gatineau to Toronto, presented at a meeting of the Toronto Section, February 22, 1929.

**District Prize for Initial Paper.** Edward M. Ashworth for his paper *The Electrical Engineer and the Public*, presented at a meeting of the Toronto Section, March 14, 1929.

## ENGINEERING FOUNDATION

### DANIEL GUGGENHEIM GOLD MEDAL AWARD

Doctor Ludwig Prandtl, professor at the University of Goettingen, Germany, and one of the world's eminent authorities on aerodynamics, has been awarded the second Daniel Guggenheim Gold Medal, this year given for "pioneer and creative work in the theory of aerodynamics," it is announced by Doctor Alfred D. Flinn, Secretary and Treasurer of the Daniel Guggenheim Fund for the Promotion of Aeronautics.

Arrangements for presentation of the medal will be completed after further communication with Dr. Prandtl, in Germany. The first award was made to Orville Wright a year ago, and the medal was presented to him in Washington, in connection with the celebration of the Fiftieth Anniversary of the American Society of Mechanical Engineers.

### OTHER RECENT EVENTS

The *Arch Dam Investigation* has drawn several foriegn contributions of information. Observations are being made on several large dams from Mexico to Oregon and the Bureau of Reclamation is preparing to test a model of the latest design for Boulder Canyon Dam in laboratory of Colorado University near Denver, where it has been cooperating with the committee in charge.

*Alloys of Iron Research* is going forward energetically at the Foundation's offices in New York, Battelle Memorial Institute, Columbus, Ohio, Lehigh University, Carnegie Institute of Technology, and Bureau of Standards almost wholly on the critical review of the literature. Subscriptions obtained by American Iron and Steel Institute now total $26,000 a year, and those by Engineering Foundation (including its appropriation), $20,000, or an aggregate of $230,000 for five years. Minimum need was estimated at $150,000. More contributions may be received.

For the *Wire Rope Research* of A. S. M. E., a strong committee representative of the interests has been appointed and is formulating a program based on much information already obtained. Investigations of *Strength of Gear Teeth*, *Lubrication* of bearings, *Cutting Fluids* for cooling and lubricating tools cutting metals are progressing well.

Studies of *Fundamental Properties of Dielectrics*, an A. I. E. E. project at Johns Hopkins, is now devoted to insulating liquids, especially oils, used in condensers, transformers, and cables.

Dr. C. V. Mann's book on Objective Type Tests is being printed and the research in *Engineering Aptitude Tests* will be the subject of intensive work at the Missouri School of Mines and Metallurgy this summer. *Personnel Research Federation*, one of Foundation's offsprings, has achieved remarkable savings of life, limb, and money in street transportation and has given counsel to personnel researches in industries, government service and education that are yielding valuable results and getting widespread attention.

Visitors and correspondence from many countries find their ways to Foundation office. There are many inquiries for information from various parts of our own country also. *Research Narratives* continue in demand.

## Book Reviews

WORKED EXAMPLES IN ELECTRICAL TECHNOLOGY. By F. Peasgood and H. J. Boyland. London and New York, Oxford University Press. 220 pp., 5¾ x 8½ in., cloth, illustrated, 1929. Price $5.00.

The book consists of a carefully graded series of mathematical examples designed to supplement the college course in electrical engineering. It covers an extensive field in power engineering and involves only simple mathematics. The scheme followed is to solve only one problem of each type and at the end of each section a number of other problems are given for the student to solve. The work is divided into three major parts, 1, the direct current circuit, 2, the magnetic circuit, and 3, the alternating current circuit; and under each head the examples are nicely graded and follow the development of the subject from the simplest to the most complicated problems. It should be found useful to the student of electrical engineering and is intended only as a supp'ement to the usual work of the student, as it contains little descriptive or explanatory text aside from numerical examples.

STANDARD WIRING FOR ELECTRIC LIGHT AND POWER. By H. C. Cushing, Jr. Published by the author, New York, N. Y. 512 pp., 4¼ x 6¾ in., flexible leather, illustrated, 1930. Price $3.00.

This well-known authority on wiring is now in its 36th year and the 1930 edition has been very completely revised with the cooperation of the engineering departments of the National Electric Light Association and the Society for Electrical Development. Its scope is broad, covering both indoor and outdoor wiring construction and distribution. The contents of the1930 edition include explanations and illustrations of the National Electrical Code, the "Red Seal" wiring plan, the "Franklin Specifications" for lighting industrial and public buildings. New chapters on inside and outside wiring, besides general information on the installation of motors, generators, lighting and wiring numerous types of buildings. A chapter on definitions of technical terms has been revised to agree with A. I. E. E. Standards. The new edition is both complete and comprehensive.

TRANSMISSION NETWORKS AND WAVE FILTERS. By T. E. Shea. New York, N. Y., D. Van Nostrand Company, Inc. 470 pp., 6½ x 9¼ in., cloth, illustrated, 1929. Price $6.50.

This is one of a series of books written by members of the Bell Telephone Laboratories and has a background of research in all phases of electrical communication. As the author states, the text may be regarded as synthesizing contributions of a large number of scientists. It was originally prepared for a course of instruction in the Bell Telephone Laboratories and was revised for presentation at the electrical engineering department of the Massachusetts Institute of Technology. The contents include an introductory chapter on the place of transmission networks in electrical communication systems and the balance of work is divided into three main parts; 1, principles of transmission networks; 2, electric wave filters; and 3, composition of transient waves. The mathematical and electrical theory of the subject is given together with a detailed treatment of the apparatus. Formulas are given for different kinds of networks, properties of wave filters are explained and recurrent signals and transients are analyzed. The book offers a very complete presentation of telephone networks and wave filters.

## PERSONAL MENTION

PHILIP S. BIEGLER, at the end of the present academic year, will become Dean of the College of Engineering at the University of Southern California, instead of Acting Dean, the office which he has held since the formation of the College in 1928.

FARLEY OSGOOD, Past-President of the Institute and formerly Vice-President and General Manager of the Public Service Electric and Gas Company of New Jersey, has been elected a Vice-President and Director of the Security Distributors Corporation.

CLYDE C. WHIPPLE, Assistant Professor of Electrical Engineering at the Polytechnic Institute of Brooklyn, has been granted leave of absence for one year, to serve as a visiting professor in electrical engineering at the Green School of Engineering of Princeton University.

Roy Page was elected vice-president of the Nebraska Power Company, Omaha, Neb., the position made vacant when J. E. Davidson was made President of the company. Mr. Page was recently appointed General Manager; his position is now Vice-President and General Manager.

John W. Bennett, who has been Distribution Engineer for the Eastern New Jersey Power Company, at Asbury Park, N. J., is now employed by the Western Massachusetts Companies, specializing in distribution design (especially underground distribution) in the City of Springfield.

A. Fred Hansen, who, for many years was connected with the Excel Electric Corporation of Beverly Hills, California, as Electrical Engineer in charge of commercial design and construction, has recently become associated with the General Electric X-Ray Corporation of Chicago as Electrical Engineer in the Export Department; with duties to be assumed abroad.

C. H. Courser, formerly General Manager of the American Utilities properties, Orlando, Florida, recently purchased by the Associated Gas & Electric Company, has succeeded G. C. Hyde as Vice-President and General Manager of the Florida Public Service Company, a subsidiary of the General Gas & Electric Corporation and a part of the Associated Gas & Electric System.

M. M. Kenneally, according to announcement made by the Ohio Brass Company, has been transferred from the New York office of the company, to Mansfield, to assume the position of Sales Manager of the power utilities department. Mr. Kenneally has been associated with the Ohio Brass Company in various capacities for the past three years. Previously he was operating engineer of the Iowa Public Service Company but transferred to the Philadelphia office as Assistant to the electrical engineer of all U. G. I. properties.

## Obituary

**Bryon C. Wolverton,** born in Portland, Maine, April 4, 1863, died at Clifton Springs, New York, April 22, 1930. He joined the Institute as an Associate in 1890 and in 1895 was transferred to the Member's grade. His general education was acquired at Starkey Seminary and his technical knowledge, under private tutelage in the laboratory. He was first employed as Telegraph Operator by the N. C. Railroad and in 1884 was appointed Electrician of the New York & Pennsylvania Telegraph and Telephone Company, for which he had done work prior to that date. This position required of him the design and construction, as well as the installation, of all apparatus and appliances used by the company, with charge of the company's shops, all materials used, and general supervision of all technical work. His work also included the making of estimates construction of apparatus, and the installation and care of all switchboards in Central Offices; in fact everything that appertained to equipment used by the company in the pursuit of business. This involved not only the electrical side of operation, but the mechanical as well. Most of his professional work, however, was devoted to the field of telephony, and his position at the time of his death was Chief Engineer of the Friendship Telephone Company, New York, N. Y., the interests of which he has served for many years. He had been made a Member for Life of the Institute.

**Alvin Meyers**, Assistant Professor of Electrical Engineering at the University of Wisconsin and an Associate of the Institute since 1902, died April 23, 1930 at the Madison Hospital, at which he had undergone a second operation, from the shock of which he was unable to recover.

Born at Verona, Wis., Oct. 5, 1872, he spent his early boyhood on his father's farm. He attended the rural schools and Stoughton Academy. After teaching for several years in rural schools, he developed an interest in engineering and entered the University of Wisconsin from which he was graduated in Electrical Engineering in 1901. In recognition of his outstanding scholastic work and his influence in the engineeering college, he was elected to membership in the honorary engineering fraternity, Tau Beta Pi.

After graduation he entered the field of hydroelectric construction during its pioneer period in the West. His joy in good workmanship and his ability as an organizer led to his rapid advancement and he served as engineer and superintendent of construction on a number of large scale hydroelectric, and steam electric plants and transmission lines in Utah, Idaho, Montana, Washington, Oregon and Texas.

But his early interest in teaching led him to return to the University of Wisconsin in 1910 as Assistant Professor of Electrical Engineering.

Professor Meyers was active on the Membership and Attendance Committee of the Institute's Madison Section.

**George W. Patterson,** A Fellow of the Institute since 1913 and Assistant Dean of the College of Engineering, University of Michigan, Ann Arbor, Michigan, died May 22, 1930, after an illness of two months.

He was born at Corning, New York, February 1, 1864 and was educated at Yale, Massachusetts Institute of Technology, Harvard, and the University of Munich. He had been a member of the Michigan teaching staff since 1889, after his first eleven years of service there, becoming Professor of Electrical Engineering. Two of his contributions to technical literature are "Industrial Photometry" (1901) and "Revolving Vectors" (1911). He was President of the Patterson Library at Westfield, N. Y., and a Director in several railroad companies.

## Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, together with the addresses as they now appear on the Institute records. Any member knowing the present address of any of these members is requested to communicate with the Secretary at 33 West 39th St., New York.

All members are urged to notify Institute headquarters promptly of any changes in mailing or business address, thus relieving the member of needless annoyance and assuring the prompt delivery of Institute mail, through the accuracy of our mailing records and the elimination of unnecessary expense for postage and clerical work.

Bakker, J. B., 440 Hyde St., San Francisco, Calif.
Birdsall, W. T., 6 Vincent Place, Montclair, N. J.
Borden, Douglas C., 19 Converse Court, Burlington, Vt.
Brown, Garry E., 1280 Dean St., Brooklyn, N. Y.
Collinot, Marcel A., F. W. V. Rm. 1050, 11 W. 42nd St., New York.
De Camargo, F. F., Post Office No. 31, E. Sao Paulo, Brazil, S. A.
DeCamp, H. H., 414 Ella St., Wilkinsburgh, Pa.
Degener, F. S., 1015 Casgrain Ave., Detroit, Mich.
De Salis, H. W., Box 66, Fort Frances, Ont., Can.
Duncan, W. C., 1121 Bedford Ave., Brooklyn, N. Y.
Fick, Ernest, A. T. & T. Co., 412 S. Market St., Chicago, Ill.
Fortin, R. P., Elec. & Gas Inspection Ser., 125 Prince William St., St. John, N. B., Can.
Gartenman, J. E., P. O. Box 19, Eastside, Providence, R. I.
Gatternigg, R., Minarets, Calif.
Gioga, Peter, Metropolitan Sound Studios, 1040 N. Las Palmas, Hollywood, Calif.
Goldsborough, James, 50 Church St., Rm. 1272, New York.
Goldsman, J. L., 100 High Holborn, London, England.
Gorrissen, Chas., Hermanstrasse 38, Hamburg, Germany.
Haggerty, J. J., 28-15 Newtown Ave., Astoria, N. Y.
Hamrick, G. R., Sweetwater, Tex.
Hardey, John E., Nat'l. Electrical & Engg. Co., Ltd., Box 1055, Wellington, N. Z.
Hershey, H. E., Midwest Athletic Club, Madison St. & Hamlin Ave., Chicago, Ill.

Hyatt, C. Brown, Camac and Medary Sts., Philadelphia, Pa.
Irvine, H. B., 1 Union St., Schenectady, N. Y.
James, Edgar A., 912 S. Poplar St., Allentown, Pa.
Keegan, W. G., 767 Maple Ave., Los Angeles, Calif.
Kirkland, E. H., 6701 Cregier Ave., Chicago, Ill.
Klien, F. A., 1215 Locust St., Philadelphia, Pa.
Ludwig, L. R., 1310 Hay St., Wilkinsburg, Pa.
Matthews, R. F., 123 Livingston St., Brooklyn, N. Y.
McDougall, D. J., 1501 W. Pierce St., Phoenix, Ariz.
McIvor, J. G., Bell Tel. Labys., 463 West St., New York, N. Y.
Nims, F. D., 70 State St., Boston, Mass.
Noome, C., Catharijnesingel 33, Utrecht, Holland.
Patrick, R. A., 425 Granite St., Reno, Nev.
Peirce, H. B., International Gen. Elec. Co., Schenectady, N. Y.
Quaas, Richard T., 545 W. 156 St., New York, N. Y.
Richman, S. L., 6823 McPherson Blvd., E. Pittsburgh, Pa.
Rivers, H. D., 298 Central Ave., Lynbrook, L. I., N. Y.
Sachse, A. O., 87 Court St., Newark, N. J.
Saliba, G. J., 311 86th St., Brooklyn, N. Y.
Schnake, H. C., 7 E. 42nd St., New York, N. Y.
Schnug, Geo. J., 9 Garrison Ave., Jersey City, N. J.
Simons, J. J., Elec. Research Prod. Co., 525 Walnut St., Cincinnati, Ohio.
Singer, R. H., 2214 Auburn Ave., Cincinnati, Ohio.
Skinner, R. W., 550 5th Ave., Parnassus, Pa.
Slaboski, H. T., 1441 Main St., Northampton, Pa.
Smedberg, O. L., 916 12th St., Oregon City, Ore.
Stern, Emery, 1030 Carroll St., Brooklyn, N. Y.
Stone, Walter, 4501 Malden St., Chicago, Ill.
Stotler, E. J., Transcontinental Air Transport Inc., Syndicate Trust Bldg., 10th & Olive Sts., St. Louis, Mo.
Syed, Mustafa, 960 S. 9th St., Noblesville, Ind.
Tsatsaron, Nicholas, Central Restaurant, 300 W. 40th St., New York, N. Y.
Velasco, L. R., Apartado 8, Canargo, Cheh, Mex.
Voegli, R., Byllesby Eng. & Mngt. Corp., Pittsburgh, Pa.
Watts, W. E. G., General Delivery, San Francisco, Calif.
Wheeler, R. E., 345 W. 58th St., New York, N. Y.

# A. I. E. E. Section Activities

### FINAL MEETING OF NEW YORK SECTION

On the evening of Friday, May 23, the New York Section held its final meeting for the year 1929-30. The meeting, held in the Engineering Auditorium was devoted to the subject "Policing Our Great City." Police Department officials described the training and coordinating of the work of the 19,000 men composing the force, including the detective squads, the marine and flying squads, the Statistical Department, the Bureau of Missing Persons, etc. Every talk proved intensely interesting to the 450 attending members. The speakers were, as follows: Police Commissioner Edward P. Mulrooney, on "The Police Department;" Inspector Joseph J. Donovan on "Some Unique Department Statistics;" Captain J. H. Ayres on "Missing Persons;" Lieutenant F. E. Zwirz on "Fingerprints and Their Use;" Sergeant H. F. Butts on "Ballistics." Motion pictures of the police parade and review were shown as well as interesting slides illustrating points in some of the talks.

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### NEW YORK SECTION AND GROUP OFFICERS FOR 1930-31

The work of the New York Section for the year 1930-31 will be taken over on August 1, 1930 by the following officers.

New York Section Executive Committee: J. B. Bassett, Chairman; C. R. Jones, Secretary-Treasurer; H. P. Charlesworth, Junior Past Chairman; and W. S. Gorsuch and J. F. Fairman.

*Power Group:* W. S. Hill, Chairman; R. F. Brower, Vice-Chairman; J. E. McCormack, Secretary; and J. M. Comly, M. J. Adrain, L. E. Frost and J. D. Winans members of Executive Committee.

*Transportation Group:* A. G. Oehler, Chairman; W. S. Hamilton, Vice-Chairman; Norman Litchfield, Secretary.

*Illumination Group:* A. L. Powell, Chairman; Isaac Mark, Vice-Chairman; W. A. Boden, Secretary.

*Communication Group:* A. F. Dixon, Chairman; F. H. Kroger, Vice-Chairman; I. S. Coggeshall, Secretary.

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### FOURTH MEETING OF CHICAGO SECTION POWER GROUP

"Present Practises and Future Trends in Power Station Design" was the subject discussed at the fourth meeting of the Power Group of the Chicago Section on April 9th. The speakers were Messrs. A. M. Rossman and F. W. Martin, of Sargent & Lundy. The meeting was well attended and created considerable interest as evidenced by the lively discussion of many points.

Mr. Martin gave a review of the mechanical features of power station design. He covered the trend in steam pressures and temperatures, and stated that a temperature of 850 deg. fahr. proposed for one installation will show a slight red glow from steam pipes and valves in a dark room. The regenerative heat cycle was discussed and two typical heat balance diagrams shown. The changes in boiler design as influenced by higher temperature, higher steam pressure and powdered fuel were shown by slides of typical designs. He stated that boilers of recent design using powdered fuel have but approximately ten per cent of the total heat absorbing surface in the boiler proper, the balance being in the superheater, economizer, air heaters and water cooled walls. These new boilers give a steaming capacity of about four times the steaming capacity of the older type boilers for the same space occupied. Coal handling and ash disposal systems, flue dust removal, boiler control and the various types of turbines were also discussed.

Mr. Rossman gave a review of the electrical features of power station design. He stated that system interconnection had been largely responsible for the present use of large turbine units and pointed out some of the problems accompanying the application of the larger units such as the need for higher generator voltage, multiple windings, etc. He showed the trend toward supplying power to the Chicago area from plants located outside of the city where condensing water and coal facilities are better. He also mentioned the proposed 220-kv. transmission of power from the Powerton Station, located approximately 150 miles from Chicago. Metal clad switching structures for main and auxiliary circuits were described and shown in a number of slides. The many advantages of metal clad switching equipment were brought out, such as factory fabrication, simplified housing, salvage value, safety features and standardization. A new type of A. C. adjustable speed motor drive for station auxiliaries, which provides a wide speed range in a simple and efficient manner was illustrated. Two of these adjustable speed motor drives have been in successful operation driving coal pulverizer mills at the State Line Station for the past year, and twenty-four more of them, aggregating over 7000 hp., are now being built for driving forced and induced draft fans at the Powerton Station. A new and simple form of automatic combustion control which has been developed in connection with the new adjustable speed motor drive was described.

## JOINT SECTION MEETING IN VIRGINIA

A joint meeting of the Southern Virginia Section of the Institute and the Virginia Sections of the A. S. C. E., A. S. M. E., and American Chemical Society was held at the Virginia Polytechnic Institute Branch, Friday and Saturday, April 25 and 26, 1930. The registration at the meeting was 118.

### Friday Afternoon

F. F. Harrington, A. S. C. E., presiding.

Welcome to V. P. I., President Julian A. Burruss.

*Coordination between Industries and Educational Institutions*, by Ambler Johnston.

*Ancient Water Works*, by Professor Francis J. Sette, V. P. I.

*County Engineering Work*, by Allen Seville, Consulting Engineer, Richmond.

*Research and Industry*, by Dean Earle B. Norris, V. P. I.

Retreat Parade, V. P. I. Cadet Corps.

### Friday Evening

Banquet. H. C. Leonard, Chairman, Southern Virginia Section, A. I. E. E., Toastmaster.

*Power Preparedness for Industry*, by E. W. O'Brien, A. S. M. E., Editor, *Southern Power Journal*, Atlanta.

*The Engineers' Day*, by L. W. Wallace, Executive Secretary, American Engineering Council.

### Saturday Morning

Saturday forenoon was devoted to an inspection of exhibits in the engineering laboratories and shops, and the morning program was concluded by a bridge building demonstration given by the Engineers' Corps Unit, R. O. T. C.

### Saturday Afternoon

Victor Serbell, A. S. M. E., presiding.

*Modern Methods of Vocational Training*, by G. Guy Via, Supervisor of Apprentices, Newport News Shipbuilding & Dry Dock Co.

Discussion, by C. F. Bailey, Engineering Director, N. N. S. B. & D. D. Co.

Track Meet—Duke University *vs.* V. P. I.

### Saturday Evening

The Saturday evening session was held under the auspices of the Virginia Section, American Chemical Society, including the Southwest Virginia Chemists Club. Following a dinner E. H. Cox, Chairman of the A. C. S. Section, presided, and the following address was presented: Ancient and Modern Alchemy, by Dr. S. S. Negus, Head of Chemistry Dept., Medical College of Virginia, Richmond.

The program of the meeting was concluded by an Engineers' Dance.

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## DINNER SMOKER OF CHICAGO SECTION

The last meeting of the 1929-30 season of the Chicago Section was a dinner-smoker held May 14, in the Bal Tabarin of the Hotel Sherman in Chicago. The attendance was over 400 and not one of those present expressed himself as dissatisfied with the meeting. A striking feature was the small part which professional entertainment played in the program. It was felt that the members of the section would be brought closer together and made better acquainted with each other if reliance were placed upon the members themselves for the major part of the entertainment. Accordingly a number of representative groups in the Section were requested to prepare and present such acts as talent was available for. The result was extraordinarily successful. It contributed no little to the success of the party to have the entertainment originate in the Section. The Commonwealth Edison Company members put on an elaborate sketch. Members associated with the General Electric Company put on another; the Public Service Company of Northern Illinois furnished a magician from among their employees. The Illinois Bell Telephone Company produced a telephone operator who could sing as well as say "The line is busy," and who directed a large chorus of men from that organization. Lewis and Armour Institutes which furnish a large number of the Student Members of the Section each contributed vaudeville acts of professional caliber. The season just concluded has been an extraordinarily successful one for the Chicago Section from all points of view and the dinner-smoker proved itself to be a highly enjoyable and very fitting wind-up to the season's activities.

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## PAST SECTION MEETINGS

### Akron

*System Planning*, by E. C. Stone, Duquesne Light Co., and Vice-President District No. 2, A. I. E. E. Dinner preceded the meeting. April 11. Attendance 60.

### Baltimore

*Electrical Work of the Bureau of Standards*, by E. C. Crittenden, Bureau of Standards, Washington, D. C. February 21. Attendance 75.

*The Quest of the Unknown*, by Professor Harold B. Smith, President of the Institute. Illustrated. Dinner preceded the meeting. April 1. Attendance 85.

*The Manufacture of Telephone Cable and Description of the Point Breeze Plant of the Western Electric Co.*, by John Wells, Western Electric Co. Illustrated. J. R. Baker read a paper relating to the Fiftieth Anniversary of the A. S. M. E. Joint meeting with the A. S. M. E. and The Engineers' Club. April 10. Attendance 200.

Inspection trip to the Western Electric Co. April 11. Attendance 150.

### Boston

*Oil Circuit Breakers*, by E. B. Merriam, General Electric Co. Short talk by I. E. Moultrop, Edison Electric Illuminating Co., outlining his recommendations for improving attendance at meetings. March 4. Attendance 85.

### Cleveland

*Factors Entering into the Manufacture of Electrical Hardware*, by Fred L. Wolf, Ohio Brass Co. April 17. Attendance 112.

### Connecticut

*Lightning Studies and Field Surge Investigations*, by Charles L. Fortescue, Westinghouse Elec. & Mfg. Co. Meeting held at Hartford Electric Light Company, preceded by dinner at Hartford City Club. April 17. Attendance 53.

### Dallas

*Lightning Studies and Field Surge Investigations*, by J. H. Cox, Westinghouse Elec. & Mfg. Co. April 18. Attendance 95.

### Detroit-Ann Arbor

*The Deion Circuit Breaker*, by Joseph Slepian, Westinghouse Electric & Mfg. Co. April 22. Attendance 150.

### Erie

*Twenty-Five Years of Experience in Electric Welding*, by James Burke, Burke Electric Co. Illustrated. April 15. Attendance 85.

### Fort Wayne

Three photophone films presented, as follows: "Oil Films on Water," "Constitution and Transformation of The Elements," "Radio—Active Rays." April 10. Attendance 200.

### Houston

*Long Distance Lines Development*, by G. A. Dyer, Southwestern Bell Telephone Co. Illustrated. Inspection of the toll office of the Southwestern Bell Telephone Co. before and after the meeting. April 25. Attendance 52.

### Indianapolis-Lafayette

*The Engineer Goes to Court*, by Professor C. F. Harding, Purdue University;

*Improvements in Electric Elevator Operation*, by C. A. Fay, Westinghouse Electric & Mfg. Co.;

*Unusual Engineering*, by D. J. Angus, Esterline Angus Co. February 14. Attendance 50.

*System Relaying and Switching Problems*, by E. H. Bancher, General Electric Co. Illustrated. March 21. Attendance 57.

**Ithaca**

*Pioneer Inventions and Pioneer Patents*, by Frank Keiper, Attorney-at-Law, Rochester, N. Y. April 9. Attendance 100.

Annual banquet held jointly with A. I. E. E. and A. S. M. E. Student Branches. Speakers—Professor Harold B. Smith, President of the Institute, and L. W. Wallace, Executive Secretary, American Engineering Council. April 18. Attendance 100.

**Kansas City**

*Your Chances to Live*, by Frank Lynch, Director, Kansas City Safety Council;

*The Use of Electricity in Cracking Hydro-Carbons*, by H. R. Rowland, Moody Engineering Company. Buffet luncheon served. April 22. Attendance 36.

**Lehigh Valley**

Inspection trip through the Bell Telephone Building. Dinner followed, after which L. F. Weldon, Hanna Engineering Co., gave a lecture on riveted steel, illustrated with a two reel film entitled, "This is the Age of Riveted Steel." *Sound Pictures, A Product of Research*, by Paul B. Findley, Bell Telephone Laboratories, Inc. Illustrated. Joint meeting with the Engineers' Society of Northeastern Pennsylvania. December 13. Attendance 97.

F. W. Peek, General Electric Co., described the experimental laboratory at Pittsfield. *Progress in Engineering will Solve the Coal Problem*, by E. H. Suender, Madeira Hill & Co. Meeting held at Easton, Pa. January 10. Attendance 130.

George P. Muldaur, General Agent of the Underwriters' Laboratories, spoke on the Laboratories organization, purposes, and methods, and gave illustrated explanation of some of the important tests on material and apparatus in relation to fire, accident prevention, and protection. *Cement*, by N. G. Finch, Portland Cement Association. Meeting held at Wilkes-Barre, Pa. February 21. Attendance 72.

Inspection trip to the Lehigh Telephone Co., followed by dinner.

*Communication*, by E. B. Tuttle, Lehigh Telephone Co.;

*Television*, by J. O. Perrine, American Telephone & Telegaphr Co. March 14. Attendance 91.

Annual Ladies Night. *Romance of Aviation*, by Harold E. Hartney, President of the Aviation Business Bureau of New York City. Members of the Engineers Society of Northeastern Pennsylvania invited. Meeting held at Hazleton, Pa. April 25. Attendance 85.

**Los Angeles**

*Some Sound Transmission Problems*, by P. L. Johnson, Southern California Telephone Co. Illustrated. Moving pictures followed. April 8. Attendance 130.

**Lynn**

Inspection trip to the Lynn Gas & Electric Co. February 15.

*Flash Welding*, by Donald F. Frost;

*Shielded Arc Welding*, by Malcolm Thomson;

*Atomic Hydrogen Welding with Dissociated Ammonia*, by P. P. Alexander. All of the above gentlemen are connected with the General Electric Co. February 26. Attendance 350.

*Super Speeded Speech*, by John B. Taylor, General Electric Co. March 5. Attendance 437.

*Safety and Regularity in Aeronautics*, by C. F. Green, General Electric Co. March 19. Attendance 125.

Annual Banquet. *The Psychology of Laughter*, by Charles M. Newcomb. Brief address by H. H. Henline, Assistant National Secretary of the Institute. Entertainment and dancing followed. March 29. Attendance 272.

*The Shoe Industry and the Machine Era*, and *Cement Shoes*, by Charles T. Cahill. *Fiber Fastenings*, by F. C. Eastman. *Turn Shoe Machines*, by M. H. Ballard. *The Iron Man*, by L. E. Topham. All of the above gentlemen connected with the United Shoe Machinery Corp. April 9. Attendance 350.

**Madison**

K. F. Green, in charge of operation, Wisconsin Power & Light Co., N. H. Blume, Wire Chief, Wisconsin Telephone Co., and F. W. Huels, Director of Publicity, Madison Gas & Electric Co., described the physical plants of these companies and presented data concerning the utility service furnished in Madison and surrounding territory. Mr. Huels also read his play, "The Birth of a Station," a melodrama in six acts. T. A. Brown, Engineer, Madison Gas & Elec. Co., described parts of the Company's system, and C. B. Hayden, Chief Engineer, Wisconsin Railroad Commission, read a humorous letter involving a radio enthusiast's complaint to the local electric utility. April 23. Attendance 40.

*Engineering, East and West*, by C. E. Skinner, Assistant Director of Engineering, Westinghouse Electric & Mfg. Co. May 8. Attendance 40.

**Milwaukee**

*The Vacuum Tube and Its Uses Outside of Radio*, by W. C. White, General Electric Co. W. C. Elmore, Wisconsin Telephone Co., illustrated the use of the dial telephone. May 7. Attendance 175.

**Minnesota**

Talks and discussions on induction coordination, meters, electrical apparatus, prime movers, distribution systems, etc. Joint meeting with the North Central Electric Association. February 24.

Banquet. February 25.

*Large Steam and Hydraulic Turbine Generators*, by S. H. Mortenson, Allis Chalmers Mfg. Co. April 30. Attendance 40.

**Nebraska**

Joint meeting with the A. S. M. E. and student members of the Universities of Nebraska and South Dakota. The students visited various industries in Omaha followed by dinner at which they were guests of the Section. April 15. Attendance 143.

**Niagara Frontier**

*The Human Element in Accident Causation*, by Frank E. Redmond, Educational Director, Associated Industries of New York State, Inc.;

*By-Products of Radio*, by Phillips Thomas, Westinghouse Elec. & Mfg. Co. March 21. Attendance 575.

*Use of Regulators in Industry*, by J. H. Ashbaugh, Westinghouse Elec. & Mfg. Co. Dinner preceded the meeting. April 18. Attendance 85.

**Oklahoma City**

*New Developments in Electrical Equipment During 1929*, by L. B. Bass, General Electric Co.;

*Developments in the Light and Power Industry During 1929*, by R. F. Danner, Oklahoma Gas & Electric Co.;

*Recent Features in Transformer Design, and in Substations for Supplying Power to Rural Communities*, by George Pingree, General Electric Co. Refreshments served. April 24. Attendance 35.

**Philadelphia**

*Circuit Interrupters*, by Joseph Slepian, Westinghouse Elec. & Mfg. Co. March 10. Attendance 250.

*The Quest of the Unknown*, by Professor Harold B. Smith, President of the Institute. Illustrated. April 2. Attendance 100.

**Pittsburgh**

Inspection trip through the Homestead Steel Plant. April 12. Attendance 352.

**Pittsfield**

*A-C. Networks*, by D. K. Blake, General Electric Co. March 18. Attendance 200.

**Portland**

*Inductively Loading Telephone Cables*, by Professor A. L. Albert, Oregon State College;

*The Portland—Salem Underground Cable Project of the Pacific Telephone & Telegraph Co.*, by A. K. Morehouse, Pacific Telephone & Telegraph Co. Buffet luncheon followed. April 16. Attendance 50.

*A Month in Soviet Russia*, by Joseph S. Thompson, President, Pacific Electric Mfg. Co., San Francisco, Calif. April 29. Attendance 167.

**Providence**

*Shall Providence Participate in the Growth of the World Trade of the United States?*, by Clemens J. France, Providence Chamber of Commerce. Joint meeting with the Providence Engineering Society. February 18. Attendance 90.

*Adequate Industrial Lighting*, by Allen M. Perry, Managing Editor, *Electrical World*. Joint meeting with the Illuminating Engineering Society. March 11. Attendance 70.

*Distribution Problems and A-C. Networks*, by D. K. Blake, General Electric Co. April 8. Attendance 85.

*The Quest of the Unknown*, by Professor Harold B. Smith, President of the Institute. Illustrated. Joint meeting with the New England Sections of the A. I. E. E. April 25. Attendance from Providence Section 30.

**Rochester**

*Bonds Between Science, Engineering, and Industry*, by Dr. Robert A. Millikan, California Institute of Technology. Annual dinner meeting of the Affiliated Engineering and Architectural Societies of Rochester. April 10. Attendance 750.

*The Quest of the Unknown*, by Professor Harold B. Smith, President, A. I. E. E. Joint meeting with the Rochester Engineering Society, preceded by a dinner. April 17. Attendance 50.

**St. Louis**

*Lightning Studies and Field Surge Investigations*, by J. H. Cox, Westinghouse Elec. & Mfg. Co. Illustrated. Election of officers for the year 1930-31 as follows: C. B. Fall, Chairman; C. H. Kraft, Vice-Chairman; E. A. Forkner, Secretary-Treasurer. April 16. Attendance 65.

**Schenectady**

*Life and Laughter*, by Capt. Irving O'Hay. April 21. Attendance 220.

**Seattle**

*High-Frequency Oscillation Transformer*, by Lloyd Steele and Homer Garrison, Students, (presented by Mr. Garrison);

*Synchronous Switch and Transient Visualizer*, by Leon Oldberg, Student, (presented by R. M. Scott). Apparatus illustrating the application of the photoelectric cell on display. Joint meeting with the University of Washington Branch. April 15. Attendance 77.

**Springfield**

*The Quest of the Unknown*, by Professor Harold B. Smith, President, A. I. E. E. Meeting held jointly with other Sections in New England at Worcester Polytechnic Institute. April 25. Attendance from Springfield Section 25.

**Syracuse**

*The Circuit Breaker Using the Deion Princple*, by R. E. Dickenson, Westinghouse Elec. & Mfg. Co. March 17. Attendance 93.

**Toledo**

*Waste in Industry*, by John M. Carmody, Editor, Factory and Industrial Management. April 23. Attendance 1000.

Inspection trip through the new building of the Auto-Lite Co. May 9. Attendance 90.

**Toronto**

John Murphy, Department of Railways and Canals, Ottawa, gave an address on his trip to Japan to the World Engineering Congress. Illustrated. April 11. Attendance 92.

*Lightning Studies and Field Surge Investigations*, by E. W. Beck, Westinghouse Elec. & Mfg. Co. Illustrated. Guests of the Hamilton Branch of the Engineering Institute of Canada and the Canadian Westinghouse Co. April 25. Attendance 360.

**Urbana**

*The Operation Calculus and Its Field of Usefulness in Mathematics and Physics*, by Prof. Ernst J. Berg, Union College. April 2. Attendance 145.

**Utah**

*Electrification of a Great Open-Cut Copper Mining Project*, by Ray J. Corfield, Utah Copper Co. Illustrated. A. C. Kelm, Chairman, gave a report of his trip to Seattle where he attended the Executive Committee meeting of District No. 9. April 14. Attendance 40.

**Washington**

*The Quest of the Unknown*, by Professor Harold B. Smith, President, A. I. E. E. Illustrated. March 31. Attendance 102.

Inspection of the Chesapeake & Potomac Telephone Company's plant, preceded by an address, *A Comparison of Manual and Dial Telephone Operation*, by G. L. Weller of that company. April 15. Attendance 212.

**Worcester**

*The Quest of the Unknown*, by Professor Harold B. Smith, President, A. I. E. E. Illustrated. April 25. Attendance 350.

# A. I. E. E. Student Activities

### STUDENT ACTIVITIES AT SPRINGFIELD DISTRICT MEETING

A considerable portion of the third day of the North Eastern District Meeting, held in Springfield, Mass., May 7-10, 1930, was devoted to a District Conference on Student Activities and a student technical session.

At the first session a brief address was given by President Smith and representatives of all Branches in the District except one presented reports on their activities during the present school year. A similar report was presented by a representative of the Brown University Engineering Society which is affiliated with the Institute. The reports showed that the Branches are taking considerable interest in student speakers.

Following the session mentioned above, the Counselors, Branch representatives, and a few others attended a luncheon meeting. Professor F. M. Sebast, Chairman of the District Committee on Student Activities, was elected delegate to represent his committee at the Summer Convention. Professor C. W. Henderson, Counselor Syracuse University Branch, was elected Chairman of the Committee to take office August 1, 1930. Professor H. H. Newell, Worcester Polytechnic Institute, was elected a member of the executive committee of the District Committee on Student Activities. The place and time for the 1931 student convention was discussed, and a decision was reached to hold it during the District Meeting in Rochester, N. Y., May 6-9.

In a brief address, President Smith emphasized the magnitude of the work of the Student Branches and the effect it will have upon Section activities. Past-President Charles F. Scott gave an interesting review of some of the developments which led to the adoption of provisions for Student Branches during his administration, and National Secretary F. L. Hutchinson explained briefly the proposed plan for admitting Enrolled Students as Associates without payment of the usual entrance fee.

The afternoon technical session was devoted to the presentation of six technical papers by students, as follows:

*Plotting A Radiated Field*, by Eric R. Osborne, Cornell University.

*The Development of Magnetic Circuits in Electrical Machinery*, by Frank H. Eastman, Jr. and Arthur Kyle Wing, Jr. (Presented by Mr. Eastman.) Yale University.

*Single-Phase Loading of Three-Phase Systems*, by Robert B. Whittredge, Yale University.

*Flying Field and Airway Lighting*, by R. B. Odgen, Massachusetts Institute of Technology.

*Magnetic and Electrical Properties of Some Chromium Steel Alloys*, by F. K. Fischer, Rensselaer Polytechnic Institute.

*Radio As An Aid to Air Navigation with Emphasis Upon the Radio Beacon*, by E. M. Pritchard, Massachusetts Institute of Technology.

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### JOINT SECTION AND BRANCH MEETING IN WORCESTER

The Worcester Section and the Worcester Polytechnic Institute Branch held a joint meeting at the Institute on April 8, 1930, at which three papers were presented by students:

*The Construction of a Substation from Initial Survey to Completion*, by Percy Marsaw.

*Tests with the General Electric Company*, by Theodore J. Meschicovsky.

*Corona and Breakdown Phenomena*, by Carl Alsing.

The program was considered very interesting. The attendance was 30.

#### JOINT SECTION AND BRANCH MEETING IN COLUMBUS

The annual joint meeting of the Columbus Section and the Ohio State University Branch was held on April 25, 1930, and included a dinner and a technical program. Due to inspection trips of the juniors and seniors, the attendance was only twenty.

The following program was presented by members of the Section and Branch:

*A New Altimeter*, by R. C. Newhouse, Graduate Student, O. S. U.
*Experiences in Colombia, S. A.*, by W. S. Franklin, Senior, O. S. U.
*Nela Park*, by H. J. Channon, Junior, O. S. U.
*Ohio Power Company System*, by A. G. Gibbony, The Ohio Power Company, Mt. Vernon, Ohio.
*High-Voltage Underground Cable Installation*, by R. A. Brown, The Columbus Railway, Power & Light Co., Columbus, Ohio.

#### JOINT MEETING OF STUDENT SOCIETIES AT PRATT INSTITUTE

The third annual meeting of the three student societies in the School of Science and Technology at Pratt Institute was held on Wednesday, April 23, 1930. Plans were made under the supervision of the Student Branches of the A. I. E. E. and A. S. M. E., and the Wohler Chemical Society.

The following technical program was presented at the afternoon session:

*Type H Underground Cable, Theory and Practise*, by Wilbur M. Shober, Industrial Electrical Engineering '30.
*Modern Box Car Unloading*, by H. M. Bosland, Industrial Mechanical Engineering '30.
*The Rise of Photography*, by Stephen Marion, Industrial Chemical Engineering '30.

The technical program was followed by several entertainment features in which members of the three societies participated. Several motion pictures were shown while dinner was being served in the school cafeteria.

At the evening session, brief addresses were given by A. C. Harper, Supervisor of the Course in Industrial Mechanical Engineering; Ernest Hartford, Assistant Secretary, A. S. M. E.; A. L. Cook, Supervisor of the Course in Industrial Electrical Engineering; H. H. Henline, Assistant National Secretary, A. I. E. E.; and C. L. Mantell of the Department of Industrial Chemical Engineering. Addresses were then given by visitors as indicated below:

*High Frequency Furnaces*, by Dudley Wilcox, Ajax Electrothermic Corp.
*The World Picture of Electrical Communications*, by Lloyd Espenschied, American Tel. & Tel. Co.
*Looking Forward in Science and Engineering*, by Dr. F. C. Brown, Director of Museum of Peaceful Arts.

The meeting was considered very successful and was thoroughly enjoyed by those present. The attendance was 315.

#### JOINT MEETING OF STUDENT ORGANIZATIONS AT PURDUE UNIVERSITY

A joint meeting of the Student Branches at Rose Polytechnic Institute and Purdue University, and the Electrical Engineering Society of the University of Illinois, was held at Purdue University on April 12, 1930.

The following program was presented by students and others:

9:00 a. m. *Effects of Lightning on Secondary Distribution Systems*, by Prof. C. F. Harding, Head, School of Electrical Engineering, Purdue University.
9:30 a. m. *Features of a Million-Volt Surge Generator*, by C. T. N. Harwood, Student, Purdue University.
10:00 a. m. *Recording of Lightning on Transmission Lines by Use of the Cathode Ray Oscillograph*, by R. H. George, Research Associate, Engineering Experiment Station, Purdue University.
10:30 a. m. Intermission and inspection of oscillograph equipment.
11:00 a. m. *A 1000-Watt Crystal-Controlled Broadcasting Transmitter*, by G. E. Weist, Student, Purdue University.
11:30 a. m. *Vacuum Tube Relays*, by H. B. Stevens, Westinghouse Electric & Mfg. Co.
12:00 noon Banquet at Union Memorial Building.
1:30 p. m. Demonstration of Insulator Test at High-Voltage Laboratory.
2:00 p. m. Inspection of Radio Station.
2:30 p. m. Tour of Campus.

The meeting was considered very interesting and the attendance was 300, of whom 100 were visitors.

#### ANNUAL COLLEGE NIGHT PROGRAM OF DENVER SECTION

The annual meeting of the Denver Section for the neighboring Student Branches was held on April 18, 1930, with an attendance of 97.

Enrolled Students of the A. I. E. E. from Colorado School of Mines, University of Colorado, University of Wyoming, University of Denver, and Colorado Agricultural College, were guests of the Denver Section at a banquet, after which the following technical program was presented:

*Electricity in the Petroleum Industries*, by E. A. Renfro and Sterl C. Kincaid, Colorado School of Mines.
*Neutral Grounding Reactors for Power Systems*, by E. H. Pemberton and J. R. Outt, University of Colorado.
*Research and the Improvement of Magnetic Materials*, by Reece Achenbach, University of Wyoming.
*The Bismuth Spiral as a Means of Measuring Magnetic Fields*, by D. S. Cooper and G. W. Bindschadler, University of Denver.

#### ANNUAL STUDENT MEETING OF SAN FRANCISCO SECTION

The annual joint meeting of the San Francisco Section and the University of California, University of Santa Clara, and Stanford University Branches was held at the University of California on April 11, 1930, with an attendance of 126, including 50 Institute members.

The technical program presented by Students was as follows:

*Heat Flow from Underground Cables*, by T. L. Selna and G. W. Vukota, University of Santa Clara. (Presented by Mr. Vukota.)
*Neon Tube Stroboscope Transformer Design*, by J. S. Low, Stanford University.
*Oscillations within a Triode of the Barkhausen and Kurz Type*, by L. J. Black, University of California.

The papers were carefully prepared and were very well presented with lantern slides, models, and graphs. An interesting discussion followed the papers.

At a dinner preceding the meeting, musical selections were given by members of the Branches. Professor A. H. Schaefer of the Electrical Engineering Department of the University of California acted as toastmaster, and brief addresses were given by Dr. L. F. Fuller, Chairman, San Francisco Section; C. E. Fleager, Vice-President, District No. 8, A. I. E. E.; and F. R. Norton, Chairman, University of California Branch.

#### STUDENT MEETING OF BOSTON SECTION

On March 25, 1930, the Boston Section held a joint meeting with the students of Harvard University, Massachusetts Institute of Technology, Tufts College, and Northeastern University. The attendance was 205, and this was considered one of the most successful and enjoyable meetings during the year.

At a dinner which preceded the program, special efforts were made to bring about closer relations between the students and the practising engineers. Members of the Boston Section were

divided into groups according to the types of engineering activities in which they are engaged. Students particularly interested in certain divisions of electrical engineering were seated with practising engineers engaged in those divisions, there being two engineers and six students at each table.

The principal address of the meeting was entitled, *Research and the Engineer*, and was given by L. A. Hawkins, Executive Engineer of the General Electric Company Research Laboratory at Schenectady.

Brief addresses were given by Professor R. G. Porter of Northeastern University, student representative of the Boston Section, who discussed briefly the methods used for forming contacts with the students, and by the President of the Harvard Engineering Society who also spoke on student activities.

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## STUDENT PROGRAM AT PROVIDENCE SECTION MEETING

The last meeting of the Providence Section for the present year was held on April 29, and was devoted to a student program. All speakers except one are members of the Brown University Engineering Society, which is affiliated with the Institute. The following program was presented:

*Power Factor in Alternating Current Circuits*, by H. D. Blomstedt, Instructor in Electrical Engineering, Brown University.

*Thermionic Tubes*, by H. E. Darling, Student.

*Capacitor Starting of Single Phase Induction Motors*, by A. E. Nickerson, Student.

*Parallel Operation of Transformers of Slightly Different Internal Characteristics*, by J. Seegal, Student.

*Three Phase Transformations at Half and Full Voltage*, by R. R. Sproul, Student.

*Some Unexpected Factors in Manual Switching*, by H. A. Smith, Student.

The papers were very well presented and it was the consensus of opinion of those present that the meeting was of high quality. Members of the Section were so well pleased with this type of program that it is expected similar meetings will be held annually in the future. Although students from only one university were present this year, those of other neighboring engineering schools will be invited to take part in future meetings. The attendance was about 40. Refreshments were served after the program.

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## PAST BRANCH MEETINGS

### University of Akron

Four photophone films presented, as follows: "The New Cascade Tunnel," "Radio Active Rays," "Oil Films on Water," "The Electric Ship (*Virginia*)." The photophone machine was described by James Jones. March 26. Attendance 45.

*The Manual System of Switching*, by Wilbur Hoffman, Student;

*The Step-by-Step Dial System*, by W. B. Woodward, Student. Inspection trip through the Ohio Bell Telephone Building. Joint meeting with the Akron Section. April 25. Attendance 78.

### Alabama Polytechnic Institute

*High-, Low-, and No-Voltage Alarm*, by F. M. Bradley, Student;

*The Distinction between A. C. and D. C. Motors*, by Hampton Miller, Student;

*Summer's Work*, by W. W. Hill, Jr., Student. April 17. Attendance 35.

Election of officers as follows: J. A. Willman, Chairman; J. L. Stone, Vice-Chairman; C. A. Brock, Secretary-Treasurer. April 24. Attendance 43.

*The Knoxville and Tallassee Power Companies*, by E. E. Griffin, Student. K. R. Clark, Student, explained the drafting room of the Tennessee Coal and Iron Company of Birmingham and related his experiences while employed there. May 8. Attendance 34.

### University of Arizona

*Life of Samuel Morse*, by C. J. Sabin, Student;

*Owen D. Young*, by J. W. Newman, Student. March 14. Attendance 12.

*Life of Westinghouse*, by J. Hall, March 21. Attendance 11.

*Life of Lord Kelvin*, by Jack Rogers, Student. March 28. Attendance 10.

*Life of Edison*, by Carl A. Ludy, Student. April 4. Attendance 12.

*Early Development of Railroads*, by P. Hart, Student. April 18. Attendance 10.

### University of Arkansas

*Arc Welding*, by E. D. Crenshaw, Student;

*Field Form of Alternators*, by W. C. Robinson, Student;

*Lead Burning*, by Ned Muse, Student. April 23. Attendance 10.

*Vector Analysis*, by H. P. Lindsey, Student;

*Some Electrical Developments in 1929*, by L. C. Wasson, Student. Illustrated. Ned Muse elected chairman for coming year. April 30. Attendance 16.

### Armour Institute of Technology

*Know Illinois*, by M. J. Maiers, Commonwealth Edison Company. Illustrated. January 24. Attendance 45.

*Modern Telegraphy—A New Art with an Old Name*, by John H. Bell, Bell Telephone Laboratories, Inc. February 14. Attendance 55.

Business meeting. March 7. Attendance 40.

Annual Spring Smoker. March 12. Attendance 125.

*Street Lighting of Hammond, Indiana*, by C. E. Rudelius, Student;

*Electricity in Ballistics*, by H. E. Stier, Student. April 3. Attendance 60.

*Color Lighting*, by Howard L. Wright, Curtis Lighting Co. April 17. Attendance 55.

### California Institute of Technology

*Manufacturing Electrical Apparatus*, by N. E. Brown. Illustrated. Meeting preceded by luncheon. April 9. Attendance 28.

### Case School of Applied Science

Election of officers as follows: G. A. Sanow, President; Irvin J. Rand, Secretary. May 9. Attendance 32.

### University of Cincinnati

*Shading Coils and Their Application to A-C. Contactors, Relays, and Single-Phase Motors*, by A. L. Casselman, University of Cincinnati. Election of officers as follows: F. F. Osterholtz, Chairman; W. J. Lewis, Vice-Chairman; Henry Suter, Secretary; G. J. Lock, Secretary. April 16. Attendance 50.

### Clemson College

*Inspection of Tallulah Falls Development of the Georgia Power Co.* April 18. Attendance 26.

### Colorado Agricultural College

*The Incandescent Lamp*, by Glen Branch, Branch Chairman. March 10. Attendance 24.

*Alaska*, by Professor Loffus. Illustrated. March 24. Attendance 21.

Business meeting. April 14. Attendance 12.

### University of Colorado

*The Electrical Transmission of Speech and Music*, by Roy Schrodt, Mountain States Tel. & Tel. Co., assisted by W. G. Rubel of the same company. Slides and phonograph records accompanied the talk. April 16. Attendance 70.

*The Economical Relation of Holding Companies to Utility Organizations*, by John E. Loiseau, Public Service Co. of Colorado. April 30. Attendance 22.

*American Institute of Electrical Engineers*, by H. B. Barnes, Consulting Engineer. Discussion followed. May 7. Attendance 42.

### University of Denver

Open house sponsored by the Department of Chemistry and A. I. E. E. Branch. Experiments were set up and explained by students. A play entitled "A Night in Alchemy" was presented by the chemistry students and talking pictures followed. April 3-4. Attendance 1400.

Inspection of the Valmont Power Plant of the Public Service Co. of Colorado. May 6. Attendance 20.

Election of officers as follows: Harry H. Ward, President; Frank Nutt, Vice-President; Fay Olmsted, Secretary-Treasurer; Roger McDougall, Corresponding Secretary. May 7. Attendance 11.

**Drexel Institute**

*Commercial Phase of Electrical Engineering*, by Mr. Parks, Westinghouse Elec. & Mfg. Co. Refreshments served. April 23. Attendance 20.

**Duke University**

*Physical Properties of Trolley Cars and Busses*, by Erskine Ehringhaus, Student;

*Electric Locomotives*, by R. W. Fonville, Student;

*Economics of Trolley Cars vs. Busses*, by F. C. Bretholl, Student. March 4. Attendance 16.

**University of Florida**

Election of officers as follows: Clyde Booth, Chairman; J. L. Sanders, Vice-Chairman; Ernest Menendez, Secretary-Treasurer. April 21. Attendance 25.

**University of Kansas**

Twenty-second annual banquet. April 10. Attendance 144.

*General Psychology Course*, by Budd Reinhold, Student;

*The Deion Circuit Breaker*, by Merle Hammond, Student;

*Radio Theory*, by Merrill Leonard, Student. May 1. Attendance 37.

**University of Louisville**

Election of officers as follows: John G. Lips, Chairman; Robert L. Wyatt, Vice-Chairman; William E. Bailey, Secretary-Treasurer. March 28. Attendance 20.

Discussion of Branch activities. April 11. Attendance 11.

**Marquette University**

*Your Profession and Your University*, by E. R. Stoekle, Globe Union Mfg. Co. Debate—Resolved: That the Conduit Return System is Superior to the Copper Return System. Affirmative, Andrew Quinn and H. Van Pieterson. Negative, Theodore Jochem and Fred Meyer. May 1. Attendance 29.

**Massachusetts Institute of Technology**

Inspection trip to the Edison Electric Illuminating Company station at South Weymouth. February 25. Attendance 52.

*Problems of Railway Engineering*, by E. N. MacKinney, Student; *A Typical Electrification Project*, by W. E. Cullinan, Jr., Student. Dinner meeting. March 11. Attendance 60.

Inspection trip to the Simplex Wire & Cable Co. April 9. Attendance 65.

*Flying Field and Airway Illumination*, by Richard B. Ogden, Student;

*Radio as an Aid to Air Navigation*, by Edward M. Pritchard, Student. April 29. Attendance 35.

**School of Engineering of Milwaukee**

*The Structure of the Atom*, by Professor C. N. Patterson. Film—"Beyond the Microscope." T. J. Coleman, Branch Chairman, explained the advantages of Student enrolment and invited the guests to become members. April 30. Attendance 60.

**University of Minnesota**

Revision of By-laws. January 27. Attendance 75.

R. M. Hanson gave a report on the District meeting held at Chicago in December. *Broadcast Pick-up on Telephone Lines*, by Robert Campbell, Student. February 18. Attendance 50.

*Audible Light and Visible Sound*, by John B. Taylor, General Electric Co. March 26. Attendance 500.

**Missouri School of Mines**

*New Application of Old Principles*, by Prof. F. W. Frame. Professor I. H. Lovett, Counselor, presented slide pictures of the General Electric Co. Works at Schenectady.

*Applications of the Photoelectric Cell*, by E. H. Woodman, Student; *Regulation of Public Utilities*, by W. J. Berry, Student. May 9. Attendance 30.

**University of Missouri**

*Some Dope with Westinghouse*, by Burdette Holt, Student;

*Sales Department with Westinghouse*, by E. Rehagan;

*Information to Juniors with Westinghouse*, by R. S. Dunlap, Student. December 4. Attendance 28.

**Montana State College**

Film—"Greater Campus." April 10. Attendance 146.

*Photoelectric Cells*, taken from the *Electric Journal*, presented by Earl Doney, Student;

*Advantages of Metal Clad Switchgear*, taken from *G. E. Review*, presented by A. W. Greiner, Student;

*The Coolidge Dam*, taken from the *Electric Journal*, presented by Robert Erb. April 17. Attendance 15.

*Idaho Power Company Develops Farm Water Heater*, taken from *Electrical West*, presented by Norman Hovey, Student;

*Photoelectric Cells*, by Joseph Hurst, Student;

*Modern Tendencies in Illumination*, taken from the *Electric Journal*, presented by C. F. Hollensteiner. April 24. Attendance 13.

*Recent Developments in Toll Telephone Service*, taken from the A. I. E. E. Journal, presented by Frank Brown, Student;

*Russia as an Electrical Market*, taken from the *Electrical World*, presented by Ward Rightmire, Student;

*Test Rack Aids in Corrosion Study*, taken from the *Electric Journal*, presented by Roy Rydell, Student. May 1. Attendance 51.

**University of Nebraska**

Inspection trip to the Nebraska Power Company and North Western Bell Telephone Co., followed by dinner and technical program in the evening. Joint meeting sponsored by the Nebraska Section. April 15. Attendance 150.

**University of New Hampshire**

Film—"The Story of the Storage Battery." April 12. Attendance 44.

Talk on industrial power factors. Discussion followed. April 19. Attendance 41.

Film—"Along the Firing Line." April 26. Attendance 43.

**College of the City of New York**

*Mercury Vapor for Power Generation*, by B. L. Newkirk, General Electric Co. May 8. Attendance 35.

**New York University**

*Economic Considerations of Steam Electrification*, by E. C. Hanly, Student. T. S. Humphrey, Student, spoke on the operation and maintenance of radio circuits used in brokerage service aboard transatlantic liners.

*Deion Circuit Breakers*, by B. S. Anderson, Student.

*132-Kv. Underground Cable*, by Norman Schutt, Student. April 8. Attendance 16.

Inspection trip to the Waterside Station of the New York Edison Company. April 10. Attendance 16.

Films—"Automatic Substation for Edison Three-Wire Service," "Switchboard Truck Type Panels," "Railway Automatic Substation." April 15. Attendance 24.

**North Carolina State College**

Election of officers as follows: R. C. Kirk, Chairman; A. W. Hamrick, Vice-Chairman; J. H. Mauney, Secretary-Treasurer. Film—"Manufacture of Insulators." April 15. Attendance 29.

General discussion. May 6. Attendance 16.

**University of North Dakota**

Adoption of new Constitution. April 23. Attendance 15.

*Radio Vacuum Tubes*, by Robert McConnell, Student. Illustrated. Election of officers as follows: Charles J. Breitwieser, Chairman; Charles C. Libby, Vice-Chairman; Robert C. McConnell, Secretary. Refreshments. April 30. Attendance 16.

**Northeastern University**

*History and Development of the Ocean Telegraph*, by A. E. Kennelly, Harvard University. Illustrated. Refreshments. April 15. Attendance 131.

**Notre Dame University**

*The Electric Eye*, by H. B. Stevens, Westinghouse Elec. & Mfg. Co. Demonstrated.

*Ultra-Violet Ray Phenomena*, by E. Dempsey, Student;

*The Business of Designing Electrical Machinery*, by Carl Brieger;

*Biography of Andrew Ampere*, by Mr. Perone, Student. Refreshments. April 7. Attendance 1178.

Charles Melloy, Student, gave a report of the trip made by the senior class to Muscle Shoals, Alabama. *Methods of Selecting Motors*, by Mr. O'Brien, Student;

*Research Work of the General Electric Laboratories*, by H. D. Sanborn, General Electric Co. Illustrated. Refreshments. April 28. Attendance 55.

**Ohio Northern University**

*Methods of Obtaining Employment*, by Professor I. S. Campbell, Counselor. April 17. Attendance 12.

**Ohio State University**

V. A. Ketcham, Ohio State University, spoke on the proposed establishment of public speaking in the engineering curricula. April 10. Attendance 26.

**Ohio University**

Jess Best elected Secretary-Treasurer. March 6. Attendance 12.

Inspection trip to the Floodwood Power Plant. March 8. Attendance 30.

Film—"The Spraying of Oil Films on Water." March 20. Attendance 270.

*Modern Telephone Achievements*, by C. W. Jones, Athens Telephone Co. April 2. Attendance 12.

**Oklahoma A. & M. College**

*Difficulties Encountered in Commutation of High Voltage D-C. Machines*, by Prof. B. Phillips. April 9. Attendance 20.

*Origin and Construction of Electrical Meters Used in Practise*, by A. L. Corley, Jr., Student. Illustrated. Talk by Dean Donnell. April 14. Attendance 50.

Professor E. B. Phillips gave a talk on his investigations of commutation difficulties encountered in large machines. May 1. Attendance 14.

**University of Oklahoma**

*Telegraphic Pilot Wire Relay Systems*, by Mr. Browder, Oklahoma Gas & Electric Co. April 28. Attendance 18.

**Oregon State College**

*Theory of the X-Ray*, by Lewis K. Poyntz, M. D. March 13. Attendance 150.

L. T. Merwin, Northwestern Electric Co., outlined the technical part of the new Lewis River Generating Plant of the Northwestern Electric Co. April 16. Attendance 37.

Luncheon meeting. Election of officers as follows: H. Glen Barnett, President; H. H. Howell, Vice-President; Gordon N. Smith, Secretary; C. E. Boucher, Treasurer. April 21. Attendance 32.

**University of Pittsburgh**

*Development Work in Electrical Engineering*, by Mr. Dudley, Westinghouse Elec. & Mfg. Co. March 27. Attendance 82.

*Arc Welding*, by Ralph Theophilus, Student;

*Artificial Sunlight*, by John Drgon, Student. April 3. Attendance 84.

Film—"That's My Wife." *The Cooperation of the Electrical Engineers*, by Dean Holbrook. A play was given by the members of the junior and senior classes entitled, "A Class in Electrical Engineering." Demonstration by Mr. Gibson, instructor, entitled, "Light Sensitive Devices." Refreshments and music. April 3. Attendance 87.

*Comparison of Schools*, by Mr. Deibel, Student;

*Talking Movies*, by Mr. Chabot, Student. Professor H. E. Dyche nominated for reappointment as Counselor. April 10. Attendance 78.

**Pratt Institute**

*Electric Locomotives*, by Robert T. Ellett, Student;

*Storage Batteries*, by Harold Gavitt, Student. May 12. Attendance 23.

**Rhode Island State College**

Election of officers. May 3. Attendance 23.

**University of South Carolina**

Debate—Are Chain Stores Detrimental to Local Interests? Affirmative C. H. Frick and G. H. Preacher. Negative Bert Karick and R. M. Watson. No decision reached. April 11. Attendance 47.

*Newton's Second Law of Motion*, by C. H. Frick;

*Economic Results Due to the Introduction of Sound Pictures*, by H. L. Stokes. April 25. Attendance 15.

Talks by three students. April 25. Attendance 15.

**University of South Dakota**

*The Elimination of Noise in the City*, by Myron Cole, Student. March 10. Attendance 7.

Discussion of plans for the annual inspection trip and banquet under the auspices of the Nebraska Section. March 24. Attendance 9.

**University of Southern California**

Lecture and film entitled "The Electrical Transmission of Speech and Music" presented by P. L. Johnson, Southern California Telephone Co., assisted by F. B. Donaldson and and other members of the engineering department of that company. April 10. Attendance 300.

*Electrical Measurements in Flow Meters*, by Professor Sidney F. Duncan. April 23. Attendance 27.

*Electrical Applications in Oil Prospecting*, by J. Lee Smith, Student. April 30. Attendance 35.

**Southern Methodist University**

*Electrical Measuring Instruments*, by A. F. Corby, Weston Electrical Instrument Co. April 7. Attendance 29.

**Stanford University**

Three films as follows: "Making Mazda Lamps," "Power Transformers," "The Moulder." February 27. Attendance 15.

W. C. Smith, General Electric Company, gave a talk on the theory and design of transformers. Illustrated. March 5. Attendance 20.

G. T. Royden, Mackay Radio and Telegraph Co., spoke on radio frequency standardization and means for obtaining it. April 24. Attendance 17.

**Swarthmore College**

*Transformers*, by Leon A. Rushmore, Student;

*Transformer Practise*, by Robert H. Lamey, Student. April 14. Attendance 11.

E. R. Armstrong, Armstrong Seadrome Corp., Wilmington, Del., spoke on seadromes. April 17. Attendance 36.

*Commercial Vacuum Tubes*, by Lawrence E. Jewett, Student;

*Photoelectric Cells*, by Leon A. Rushmore, Student;

*The Thyratron Tube*, by Henry C. Hadley, Student. Election of officers as follows: Lewis Fussell, Jr., President; Robert H. Lamey, Secretary.

Films—"Oil Films on Water," "The Constitution of the Atom." April 25. Attendance 72.

*The Application of D-C. Single-Phase, and Three-Phase Systems*, by Robert H. Lamey, Student. April 28. Attendance 12.

*Concatenation as a Method of Speed Control for Induction Motors*, by Robert H. Lamey, Student;

*Double Squirrel-Cage and Polyphase Commutator Induction Motors*, by Lewis Fussell, Jr., Student;

*The Geometric Analysis of the Operation of Induction Machines*, by Lawrence E. Jewett, Student. May 2. Attendance 10.

*High-Frequency Salient-Pole Alternators*, by Henry Hadley, Student;

*The Testing and Operation of Synchronous Generators*, by Robert H. Lamey, Student. May 5. Attendance 10.

**University of Tennessee**

*How to Meet the Employers Wants*, by O. D. Fleming, Student;

*Calderwood Dam*, by H. R. Hastings, Student;

*Trip Made by Senior Engineering Class*, by F. P. Elam. April 9. Attendance 14.

Election of officers as follows: A. M. Howery, Chairman; G. T. Nunally, Vice-Chairman; B. A. Cogbill, Secretary. April 23. Attendance 18.

**Texas A. & M. College**

*Transatlantic Cables*, by Mr. Duncan, French Cable Co. April 14. Attendance 57.

**University of Utah**

Business meeting. April 22. Attendance 15.

Frank Young, Student, gave a talk on work he and Ray E. Griggs have done on a Vreeland Oscillator. Election of officers as follows: Fred Lundberg, Chairman; Lee Irvine, Vice-Chairman; Ray Bohne, Secretary. May 6. Attendance 23.

**University of Vermont**

Discussion of Branch activities. February 24. Attendance 13.

*Auto Valve Lightning Arresters*, by R. A. Daily, Student. March 10. Attendance 12.

Films—"Power," and "Coal is King." March 25. Attendance 38.

Discussion of plans for a five day inspection trip to include the District meeting held at Springfield. April 21. Attendance 14.

Election of officers as follows: Robert F. Bigwood, Chairman; M. L. Joslyn, Vice-Chairman; Philip H. Thomas, Secretary-Treasurer. May 5. Attendance 14.

**Virginia Military Institute**

The following talks given by Students:

*The Deion Grid*, by Mr. Romm;

*The Lavino Furnace*, by Mr. Mills;

*Steinmetz The Man and The Genius*, by Mr. King;

*Magnetic Clutches*, by Mr. Richards. April 11. Attendance 54.

Lecture by Mr. Skinner, Consulting Engineer on bridges for the State of New York. April 26. Attendance 143.

**Virginia Polytechnic Institute**

Discussion and arrangements for Engineers' Day. April 23. Attendance 20.

Talk on the history and purposes of the A. I. E. E., with special reference to Branch activities by Professor W. S. Rodman, Vice-President District No. 4, A. I. E. E. April 25. Attendance 22.

**University of Virginia**

*Lightning Arresters*, by W. B. Barnes, Student;

*Grid-Glow Tube Relay*, by G. G. Querles, Student. March 6. Attendance 9.

Ten student members attended the meeting of the Southern Virginia Section held in Norfolk at which President H. B. Smith gave his address, *The Quest of the Unknown*. March 28. Attendance 10.

Approval of minutes of previous meeting. Joint meeting with A. S. M. E. Branch. April 3. Attendance 37.

**State College of Washington**

*Engineering Achievements of 1929*, by John Harrington, Student. March 12. Attendance 24.

*Frequency Modulation*, by Lester Hatfield, Student. March 26. Attendance 23.

*Some New Vacuum Tubes and Their Applications*, by Merle Poland, Student. Hugh Tinling, Tinling and Powell, gave a description of the mercury arc rectifier equipment at the Trail Electrolytic Zinc Plant. Joint meeting with the Spokane Section. April 25. Attendance 38.

**University of Washington**

*Use of the Synchronous Switch and Visualizer Screen in the Study of Transients*, by Leon Olberg, Student. Discussion of open house plans. March 14. Attendance 26.

**Washington University**

Banquet. December 5. Attendance 21.

Sixteen student members attended the meeting of the 7th Geographical District held at Columbia, Mo. March 20, 21 and 22.

Discussion of activities. April 25. Attendance 20.

**West Virginia University**

The following talks given by Students:

*Radio Beacons for Air Craft*, by C. W. Thrall;

*Ultra Violet Light Meter*, by J. E. Newcomer;

*Effects of Electric Shock*, by R. C. Warder;

*An Ammeter for Starting Currents*, by C. F. Stewart;

*Transoceanic Telephone Service*, by P. H. Steenberger;

*The Use of Electrical Power in the Production of Building Stone*, by T. F. Manion. March 12. Attendance 46.

**Worcester Polytechnic Institute**

Inspection trip to the burglar alarm system located in the Slater Building. March 24. Attendance 16.

**Yale University**

*Symmetrical Components*, by C. L. Fortescue, Westinghouse Elec. & Mfg. Co. April 17. Attendance 20.

*Electrical Hazards*, by Thomas H. Day, New England Fire Insurance Exchange. Illustrated. April 22. Attendance 30.

# Engineering Societies Library

*The Library is a cooperative activity of the American Institute of Electrical Engineers, the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers and the American Society of Mechanical Engineers. It is administered for these founder societies by the United Engineering Society, as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West Thirty-ninth St., New York.*

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## BOOK NOTICES, APRIL 1-30, 1930

Unless otherwise specified, books in this list have been presented by the publishers. The Library does not assume responsibility for any statement made; these are taken from the preface or the text of the book.

All books listed may be consulted in the Engineering Societies Library.

Annual Survey of American Chemistry, v. 4, July 1, 1928 to Dec. 31, 1929. Edited by Clarence J. West. Published for National Research Council, by Chemical Catalog Company, N. Y., 1930. 549 pp., 9 x 5 in., cloth. $4.00.

A review of progress in various branches of pure and industrial chemistry, by various specialists. The concise reports, with their full references to the material published on each topic, enable the student to keep abreast of developments in general and to review thoroughly the new work in fields of especial interest to him.

Aluminum Industry, v. 1, Aluminum and its Production; v. 2, Aluminum Products and their Fabrication.

By Junius David Edwards and others. N. Y., McGraw-Hill Book Co., 1930. (Chemical Engineering series.) 2 v., illus., diagrs., tables, 9 x 6 in., cloth. $12.00.

These two volumes give the most extensive survey of the aluminum industry in print. Volume 1 begins with a history of the discovery of the metal and the development of the industry and then proceeds to a discussion of the ores and of their mining and refining to obtain pure alumina. It closes with a description of the production of metallic aluminum. Volume 2 discusses the properties of the metal and its alloys, the fabrication of aluminum products and their uses in transportation, building, the food and chemical industries, metallurgy, electrical engineering, etc. Bibliographies, lists of patents and references are scattered through the book. The authors are connected with the Aluminum Company of America and have drawn upon its records and experience.

American Civil Engineers' Handbook. 5th edition, rev. & enl. Edited by Thaddeus Merriman and Thomas H. Wiggin. N. Y., John Wiley & Sons, 1930. 2263 pp., illus., tables, 7 x 5 in., fabrikoid, $8.00.

The new edition of this standard reference work, the first revision in ten years, will be welcomed by engineers generally. It has been thoroughly revised, the editor states, many new cuts have been added and the entire book reset. Two hundred and fifty pages have been added.

Engineers who travel or do field work will be glad to know that a two-volume edition of the work is now available.

BALANCING OF OIL ENGINES

By W. Ker Wilson. Lond., Charles Griffin; Phila., J. B. Lippincott Co., 1929. 279 pp., illus., diagrs., tables, 9 x 6 in., cloth. $10.00.

A presentation of principles and practise, based upon long experience in the design and production of internal combustion engines. The author first surveys the principles and shows how they can be used to calculate unbalanced forces and couples, after which he analyzes engines of from one to eight cylinders in a series of chapters. Graphical methods, general design and the design of vibrationless foundations are considered. The book is suited to practical use in the designing office.

BALKENBRÜCKEN. Lieferung 2.

By W. Gehler. (Handbuch für Eisenbetonbau, bd. 6. 3rd edition. Edited by F. Emperger). Berlin, Wilhelm Ernst & Son, 1930. pp. 97-912, illus., diagrs., tables, 11 x 7 in., paper. 6,80 r. m.

This section of the revised edition of this well-known manual continues the discussion of floors for reinforced concrete bridges, and the influence of heat on these bridges, and then takes up at length the design of the supporting structure, abutments, cross-ties and bearings. A wealth of description of existing structures is included.

COLLOID SYMPOSIUM ANNUAL. 1929.

Edited by Harry Boyer Weiser. N. Y., John Wiley & Sons, 1930. 300 pp., illus., diagrs., tables, 9 x 6 in., cloth. $4.50.

Contains the twenty-three papers presented at the symposium of 1929 at the Johns Hopkins University.

LE CONTROLE DE LA DURETÉ DES METAUX DANS L'INDUSTRIE.

By P. Roudié. Paris, Dunod, 1930. 114 pp., illus., 10 x 6 in., paper. 29,50 fr.

The importance of hardness tests today has led the author to a critical review of their value to industry and of the accuracy and usefulness of the various methods of measurement in use. The advantages of these are compared, and proper methods of applying them explained.

ELECTRICAL DISTRIBUTION ENGINEERING.

By Howard P. Seelye. N. Y., McGraw-Hill Book Co., 1930. 710 pp., illus., diagrs., tables, 9 x 6 in., cloth. $6.00.

A systematic description of current practise in the design of distribution systems. Both overhead and underground distribution are considered and due attention is given to electrical, mechanical and economic requirements. The book is designed for both student and reference use and contains many tables.

ELEKTRISCHE MASCHINEN, v. 2; Synchronmaschinen und Einankerumformer.

By Rudolf Richter. Berlin, Julius Springer, 1930. 707 pp., illus., diagrs., tables, 10 x 7 in., bound. 39.-r. m.

A thorough course on the design of synchronous machines and rotary converters. The magnetic and electric phenomena are discussed very fully, and methods of designing are presented at length. The results of many special investigations are published for the first time. The author is a professor at the Karlsruhe Technical High School.

ELEMENTS OF FRACTIONAL DISTILLATION.

By Clark Shore Robinson. N. Y., McGraw-Hill Book Co., 1930. (International Chemical series). 255 pp., diagrs., tables, 8 x 5 in., cloth. $3.00.

The aim of this book is to provide engineers and operators of distilling plants with a statement of the physical and chemical principles of fractional distillation illustrated by a few selected examples.

The new edition includes much of the information obtained by recent workers on the distillation of petroleum.

FABRIKATIONSKONTROLLE AUF GRUND STATISTISCHER METHODE.

Edited by H. C. Plaut. Berlin, V. D. I. Verlag, 1930. 81 pp., illus., diagrs., 11 x 8 in., paper. 7,50 r. m.

A course of lectures on the use of statistics in production control, recently given at the Charlottenburg Technical High School. The nine lectures present the theory underlying statistics and the methods of most practical use in production control, and illustrate them by applications to the construction of electrical apparatus, telephony, the manufacture of machinery and management engineering.

FLOOD FLOWS.

By Allen Hazen. N. Y., John Wiley & Sons, 1930. 199 pp., diagrs., tables, 9 x 6 in., cloth. $4.00.

For more than twenty years, a study of the size and recurrence of flood flows has been carried on by the author and his business associates. The results of this work and that of other students of flood problems are here gathered into one compact presentation of the methods most helpful on estimating flood quantities and of controlling floods.

FORSCHUNGSHEFTE DER STUDIENGESELLSCHAFT FÜR HÖCHSTSPANNUNGSANLAGEN, heft 2. Sonderheft; Isolierstoffe.

Edited by A. Matthies. Berlin, Vereinigung der Elektrizitätswerke, 1930. 101 pp., illus., diagrs., tables, 12 x 8 in., paper. 12.-r. m.

Nine papers by various specialists on: insulating oils, the influence of water and dissolved gases on the electrical properties of dielectric liquids, the reliability of bakelized paper and molded material for high-tension equipment, failure phenomena in bakelized-paper insulators, electrical investigations of bakelized paper, the condenser electrode to prevent jump-over sparks in puncture tests, dielectric properties of hemp, dielectric strength of bitumen in relation to temperature, the electrical properties of insulating materials, especially bakelized paper. These reports cover recent experimental studies.

GUTACHTEN ÜBER DIE REICHSELEKTRIZITÄTSVERSORGUNG.

By Oskar von Miller. Berlin, V. D. I. Verlag, 1930. 69 pp. + 23 plans. 12 x 9 in., cloth. 30.-r. m.

A survey of the future electric power requirements of Germany, and a plan for supplying them, prepared for the Ministry of Economic Affairs. The report outlines an interesting plan for a national power supply which will utilize most effectively the existing power plants and provide necessary future additions to the best advantage.

INTERNATIONAL CRITICAL TABLES OF NUMERICAL DATA; Physics, Chemistry and Technology. v. 6.

By the National Research Council. N. Y., McGraw-Hill Book Co. Published for the National Research Council, 1929. 471 pp., 11 x 9 in., cloth. $12.00.

Volume six contains data on X-rays, electronics, gas conduction, dielectric properties, electrical conductivity and resistivity, pyroelectricity, piezoelectricity, thermoelectricity, magnetism, atmospheric electricity, terrestrial magnetism, and acoustics. The values given are the most accurate available. References to the original papers are given in every case. The series is indispensable to every research worker.

MANUAL OF NAVAL ARCHITECTURE.

By George Charles Manning. N. Y., D. Van Nostrand Co., 1930. 183 pp., illus., diagrs., 9 x 6 in., cloth. $2.75.

Naval architecture and ship construction are discussed here from the point of view of the operating officer, not of the designer and builder. All features of the hull are covered briefly, with emphasis on fundamental principles, the purpose being to enable the officer to understand his ship.

PHYSICS AND CHEMISTRY OF SURFACES.

By Neil Kensington Adam. Oxford, Clarendon Press; N. Y., Oxford University Press, 1930. 332 pp., diagrs., tables, 9 x 6 in., cloth. $6.00.

A discussion of the theory of surfaces from the point of view of the molecular theory. By introducing the ideas concerning the shapes and mechanical and chemical properties of molecules which the theory of organic chemistry requires into the study of surfaces, much new light is thrown upon phenomena hitherto classed as physical. The author discusses such matters as capillarity, absorption, lubrication, surface tension and catalysis from this point of view.

S. A. E. HANDBOOK. 1930 edition. N. Y., Society of Automotive Engineers, 1930. 728 pp., illus., diagrs., tables, 7 x 4 in., fabrikoid. $5.00.

The new edition of the Handbook contains the current standards and recommended practices of the Society and the specifications now in force. Over six hundred specifications are included.

STATISTICAL TABLES AND GRAPHS.

By Bruce D. Mudgett. Boston, Houghton Mifflin Co., 1930. 194 pp., illus., 8 x 5 in., cloth. $1.75.

An elementary textbook of statistical methods intended for those who consider becoming business men, not statisticians.

Emphasis is directed to those elementary statistical methods, the preparation of tables of figures and graphs, which are most used in business. The presentation is clear and refreshingly concise.

STORAGE BATTERIES.

By George Wood Vinal. 2d edition. N. Y., John Wiley & Sons, 1930. 427 pp., illus., diagrs., tables, 9 x 6 in., cloth. $5.00.

The scope of this work is indicated by its title. In a book of moderate size, Mr. Vinal summarizes the scientific principles of storage batteries that are of particular interest to the engineer and user, describes their principal uses, and tells the type of battery suited to each use. Bibliographic references are scattered through the book. The new edition includes a new section on aircraft batteries and has been thoroughly revised throughout.

STRENGTH OF SHAFTS IN VIBRATION.

By J. Morris. Lond., Crosby Lockwood & Son, 1929. 191 pp., diagrs., 10 x 7 in., cloth. 30 s.

A record of mathematical researches by the author into various problems connected with the investigation of vibration in shafts. The main features of the work, the author states, are the elegant general mathematical results obtained for any number of loads on a shaft in vibration whether lateral or torsional. The general theory is first dealt with, after which are given a number of examples illustrating the use of the methods in examining the resonant speeds of an airscrew, a dynamometer rotor, and an internal combustion engine crankshaft; and the vibrations in engine driving airscrews.

DAS TECHNISCHE LICHTBILD.

By Georg v. Hanffstengel. Berlin, V. D. I. Verlag, 1930. 114 pp., illus., 8 x 6 in., paper. 5.-r. m.

The usefulness of lantern slides and moving pictures to illustrate technical lectures depends upon the skill with which the drawings and photographs are prepared from which they are made. This little book discusses the various questions that affect the value of lantern slides and the ways in which they can be used in education and industry. Much good practical advice is given, based on experience. The book should also be useful to illustrators of technical literature and advertisements.

VORSCHRIFTENBUCH DES VERBANDES DEUTSCHER ELEKTROTECHNIKER. 17th edition. Berlin, Verband Deutscher Elektrotechniker, 1930. 1153 pp., 8 x 6 in., cloth. 18.-r. m.

The seventeenth edition of the rules of the Verband Deutscher Electrotechniker is an impressive volume of over 1100 pages, containing all the rules, standards, and specifications of the German electrical industry, as in force on January 1, 1930. Many changes from the sixteenth edition are included.

THE WRIGHT BROTHERS, FATHERS OF FLIGHT.

By John R. McMahon. Boston, Little, Brown & Company, 1930. 308 pp., illus., ports., 8 x 5 in., cloth. $2.50.

This is, we believe, the first complete history of the Wrights to appear. Their story is traced from birth to the twenty-fifth anniversary of flight in December, 1928. The style is interesting and the work is well illustrated. Every student of aviation will find it of interest.

# Engineering Societies Employment Service

*Under joint management of the national societies of Civil, Mining, Mechanical and Electrical Engineers cooperating with the Western Society of Engineers. The service is available only to their membership, and is maintained as a cooperative bureau by contribution from the societies and their individual members who are directly benefited.*

*Offices:—31 West 39th St., New York, N. Y.—W. V. Brown, Manager.*
*1216 Engineering Bldg., 205 W. Wacker Drive, Chicago, Ill., A. K. Krauser, Manager.*
*57 Post St., San Francisco, Calif., N. D. Cook, Manager.*

*MEN AVAILABLE—Brief announcements will be published without-charge but will not be repeated except upon requests received after an interval of one month. Names and records will remain in the active files of the bureau for a period of three months and are renewable upon request. Notices for this Department should be addressed to* ***EMPLOYMENT SERVICE, 31 WEST 39th Street, New York City,*** *and should be received prior to the 15th day of of the month.*

*OPPORTUNITIES.—A Bulletin of engineering positions available is published weekly and is available to members of the Societies concerned at a subscription of $3 per quarter, or $10 per annum, payable in advance. Positions not filled promptly as a result of publication in the Bulletin may be announced herein, as formerly.*

*VOLUNTARY CONTRIBUTIONS.—Members obtaining positions through the medium of this service are invited to cooperate with the Societies in the financing of the work by contributions made within thirty days after placement, on the basis of one and one-half per cent of the first year's salary: temporary positions (of one month or less) three per cent of total salary received. The income contributed by the members, together with the finances appropriated by the four societies named above will it is hoped, be sufficient not only to maintain, but to increase and extend the service.*

*REPLIES TO ANNOUNCEMENTS.—Replies to announcements published herein or in the Bulletin, should be addressed to the key number indicated in each case, with a two cent stamp attached for reforwarding, and forwarded to the Employment Service as above. Replies received by the bureau after the positions to which they refer have been filled will not be forwarded.*

### POSITIONS OPEN

MECHANICAL ENGINEER, graduate, 30-35, to take charge of the mechanical design of electric motors. Apply by letter. Salary $225-$250 a month. Location, Middle West. W-914-CS.

ELECTRICAL OR MECHANICAL ENGINEER, graduate, with three or four years' experience for production control, wage incentives, and time setting in the shops of an electric motor manufacturer. Apply by letter. Salary $175-$200 a month. Location, Middle West. W-915-CS.

EXPERIENCED ENGINEER, trained in testing and research work. Location, New Jersey. Apply by letter. W-1004.

### MEN AVAILABLE

ASSOCIATE PROFESSOR OF ELECTRICAL ENGINEERING, 42, in charge of department, would consider change to E. E. Department of college, university, or elsewhere. Experience includes 2 years' manual switchboard dept. of Automatic Elec. Co. of Chicago, 10 years' teaching. M. S. degree in communication engineering M. I. T. Available September 1st. B-7840.

ELECTRICAL ENGINEER, age 29, married; five years' broad experience in design, construction and maintenance of power plants, substations and industrial buildings. One year as instructor in large midwestern university. Employed at present but desires more permanent position. Available upon short notice. C-5734.

ELECTRICAL ENGINEER, American, 39, married. Experienced in power generation, transmission, distribution and application to industrial uses. Work covers layout, construction, operation, maintenance and repairs. Desires position as electrical engineer with manufacturing concern generating their own power or with utility company. Speaks Spanish. Available on reasonable notice. C-502.

GRADUATE ELECTRICAL ENGINEER, (executive) now employed, 33, married. Ten years' experience, design supervision of construction, generating sub- and railway-converter stations. Invites correspondence from public utility's where opportunity for advancement. Member N. E. L. A. B-6600.

ELECTRICAL ENGINEER, with five years' experience in generating station and substation design and construction, especially relay and control work, and one year of teaching experience. Desires a position in the vicinity of New York City. C-7287.

ENGINEER, having 10 years' of practical experience in transmission, distribution and road construction, is desirous of a connection with a progressive concern. Perfect knowledge of French and Russian. Location Europe. B-7412.

PUBLIC UTILITY OPERATOR is available for responsible position in U. S. A. or foreign field. Competent commercial man and practical engineer in electric, water, telephone and steam heating. Some experience in ice and gas. Especially well qualified in electric appliance merchandising and load building. C-7171.

ELECTRICAL ENGINEER, 9 years' engineering experience. Experience covers design and construction of overhead distribution and transmission systems; underground a-c. networks

and distribution systems; switchboard and substation design and operation. Executive ability. At present assistant distribution engineer. Location, Southwest or South. C-4734.

ELECTRICAL ENGINEER, age 27. One years standardizing laboratory, calibrating and testing of instruments. One year research and acceptance tests on automatic network equipment for distribution system. Six years' testing and inspection of electrical equipment in power plants. Two years' layout and design of electrical equipment for bridges. B-9349.

DISTRIBUTION ENGINEER, college graduate, age 26, single, with four years' experience in design and estimating of rural lines, feeders, and city distribution. Desires connection with broader field of activity with opportunity to study underground distribution. Available on reasonable notice. Location preferred, East. C-5454.

ELECTRICAL ENGINEER, 20 years' experience in power plant, transmission line, and factory design and testing; technical graduate; mathematical and inventive ability and ingenuity. Employed at present. Location desired vicinity of New York City. C-6542.

ELECTRICAL ENGINEER, with three years of college work. Married, 21 years old and in good physical condition. Experience in E. E. laboratories, shop—machine, pattern, forge and welding. Available by middle of June for a permanent job. C-7360.

DOCTOR OF PHILOSOPHY in Applied Electricity, 28, research experience in sound analysis, measurements, vacuum tube application to engineering problems, theoretical, experimental investigation on radio wave propagation phenomena, general electrical circuit theory. Desires position research laboratory. Academic position would be acceptable where research facilities are available. Best references. East, Middle West preferred. C-7392.

GRADUATE ELECTRICAL ENGINEER, (Columbia University), 33 years, married, ten years' various engineering experience in America and abroad. Now serving as assistant engineer with firm of consulting engineers. Desires position with a small industrial concern as maintenance engineer, or with construction or manufacturing company. B-6234.

SALES ENGINEER, technical graduate, General Electric Test, seven years' successful sales record in district office handling both industrial and central station customers. Desires connection which will lead to advancement. New England location preferred but will consider other assignment. C-7395.

ELECTRICAL ENGINEER, with profound knowledge of the fundamental theories of electricity, magnetism and general physics; thoroughly experienced design, development of electromagnetic, electromechanical applications (motors, generators, industrial controls, etc.). Now Director Research Laboratory. Would consider new connections as director of research or chief engineer of motor or industrial control manufacturer. B-4975.

ELECTRICAL ENGINEER, B. S. degree, age, 27, five years' experience in consulting engineer's office design and specifying lighting and power distribution systems for skyscraper type hotels, hospitals, and office buildings. Experience in heating, plumbing and ventilating drafting. Executive ability. Desires position. Best references. Available immediately. C-1174.

GRADUATE ELECTRICAL ENGINEER, 22, single, desires connection where knowledge of automatic telephone switching equipment and railway signal apparatus would prove advantageous. Employed at present. C-6039.

PROFESSOR OF ELECTRICAL ENGINEERING, 18 years' experience. Head of Department of Electrical Engineering in southern university. Desires change. Best of references. Degrees—B. E. in E. E., M. S. Location, South or East preferred. B-2675.

ELECTRICAL AND MECHANICAL ENGINEER, 29, married; five years' experience in test, application, maintenance and design. Past two years' in charge of electrical department for mining company. Desires connection as assistant plant engineer or assistant electrical engineer with industrial. Good personality, can handle men, willing to assume responsibility. Now employed. B-9001.

DIRECTOR OF EDUCATIONAL WORK, with large technical corporation desires position as Professor of Electrical Engineering head of department. Formerly Assistant Professor of electrical engineering at leading technical school with five years' university teaching experience. Hold B. S. in E. E. and M. S. in E. E. degree. Location, immaterial. C-7411.

GRADUATE ELECTRICAL ENGINEER, age 34. Five years' diversified experience with an Eastern public utility, inspection, appraisal, estimates, reports, budgets, distribution engineering. Three years' previous electrical experience. Wishes to obtain a position with a public utility located west of the Mississippi River. C-314.

RECENT GRADUATE, 22 years, single. 1929 graduate in engineering, desires a position with some application and use of engineering principles, that will be good experience. Available within two weeks. Location preferred, California. C-7429-305-C-S.

ELECTRICAL-MECHANICAL ENGINEER, Cornell. G. E. Shops. Five years' in each of the following lines: Railway electrification, hydro-electric irrigation projects; heavy automotive and tractor design and operation, engineering investigations and reports South America and Orient; commercial production high-tension vacuum dedevices, X-ray and neon tubes, plant equipment: Director, electrophysical laboratory research. C-7026.

GRADUATE ELECTRICAL ENGINEER, 28, married. Seven years' experience includes Westinghouse Test, distribution engineering, and engineering and construction department of public utility. Experienced in distribution layout and revamping, wood pole transmission line design, calculations, cost estimates, analyses, tax and budget work, etc. Now employed but desires new connection with greater opportunity. C-3694.

GRADUATE ELECTRICAL ENGINEER, married, 28, four years' experience as designer of electrical indicating instruments. Experienced in developing, designing, and manufacturing. Application of photoelectric cells to measuring instruments. Qualified to take charge of development and design of small electrical apparatus. Location immaterial. B-9583.

ELECTRICAL ENGINEER, junior, wishes position in the testing, standardizing, or research laboratory of a large utility or manufacturing plant. At present instructor in electrical measurements in prominent Midwest Engineering School. Has seen service in the laboratories of the large Metropolitan companies. C-7387.

PROFESSOR, ASSOCIATE PROFESSOR ELECTRICAL ENGINEERING, 39, B. S. in E. E. also electrical engineer, University of Colorado. Practical experience with power, telephone, maining and electrical manufacturing concerns. Six years' on the electrical engineering faculty of state school. Now employed but available for school year 30-31. C-5021.

# MEMBERSHIP—Applications, Elections, Transfers, Etc.

### RECOMMENDED FOR TRANSFER

The Board of Examiners, at its meeting of May 21, 1930, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the National Secretary.

#### To Grade of Fellow

BARTON, THEOPHILUS F., Engineer, General Electric Company, New York, N. Y.
FLETCHER, HARVEY, Acoustical Research Director, Bell Telephone Laboratories, Inc., New York, N. Y.
JONES, BASSETT, Member of Firm of Meyer, Strong & Jones, Inc., New York, N. Y.
SMITH, WILLIAM R., Assistant Chief Engineer, Public Service Production Co., Newark, N. J.

### APPLICATION FOR ELECTION

Applications have been received by the Secretary from the following candiates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the Secretary before June 30, 1930.

Abbott, O. C., Bristol Co., Waterbury, Conn.
Ackerman, R. W., (Member), Gold Seal Electrical Co., Newark, N. J.
Adair, J. M., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Allen, E., Public Service Co. of No. Illinois, Maywood, Ill.
Allen, W. R., United Engineers & Constructors, Inc., Newark, N. J.
Baker, F. J., Home Tel. & Tel. Co., Fort Wayne, Ind.
Bates, W. W., Wilbur-Suchard Chocolate Co., Philadelphia, Pa.
Baugh, H., Westinghouse Elec. & Mfg. Co., Houston, Tex.
Behan, G. P., Niagara Lockport & Ontario Power Co., Gardenville, N. Y.
Birkett, H. S., General Cable Corp., New York N. Y.
Blanc, V., Western Electric Co., Kearny, N. J.
Blatz, I. H., 8880 Fairmount Ave., Hollis, N. Y.
Blegen, G. C., Stone & Webster Engg. Corp., Seattle, Wash.
Bowen, D. A., (Member), Westinghouse Elec. & Mfg. Co., New York, N. Y.
Bridgman, W. K., Commonwealth Edison Co., Chicago, Ill.
Broleen, W., Habirshaw Cable & Wire Corp., Yonkers, N. Y.
Browder, J. D., Oklahoma Gas & Electric Co., Oklahoma City, Okla.
Brown, A. S., (Member), Federal Telegraph Co., Pal Alto, Calif.
Brown, K. R., Rockford Electric Co., Rockford, Ill.
Carlson, F. K., Pacific Ave. & Forrest St., Jersey City, N. J.
Case, F. E., (Member), General Electric Co., Erie, Pa.
Certner, N. M., Certner's Electric Shop, Bayonne, N. J.
Cole, C. S., Westburgh Electric Service Co., Jamestown, N. Y.
Coles, E. M., Canadian Westinghouse Co., Ltd., Hamilton, Ont., Can.
Conrey, O. W., Los Angeles Gas & Electric Corp., Los Angeles, Calif.
Coventry, E. P., Can. International Paper Co., Gatineau, Que., Can.

Davis, C. H., Northern Electric Co., Montreal, Que., Can.
De Vries, L., City Light, Seattle, Wash.
Edquist, P. E., City Light & Power, Seattle, Wash.
(Applicant for re-election.)
Eggler, E. G., Wm. Ainsworth & Sons, Inc., Denver, Colo.
Field, W. P., (Member), Westcott & Mapes, New Haven, Conn.
Fisher, A., General Electric Co., Lynn, Mass.
Fraser, F. W., Home Telephone & Telegraph Co., Fort Wayne, Ind.
Frier, C. H., (Member), Oklahoma Gas & Electric Co., Oklahoma City, Okla.
Frye, J. L., City Light, Seattle, Wash.
(Applicant for re-election.)
Geddes, L. J., Des Moines Electric Light Co., Des Moines, Ia.
Glenne, H., (Member), Voorhees, Gmelin & Walker, New York, N. Y.
Gould, S. M., Greenfield Electric Light & Power Co., Greenfield, Mass.
Gruehr, A. R., (Member), New York Edison Co., New York, N. Y.
Gushue, F., C. H. Tenney & Co., Boston, Mass.
Harper, R. G., Westinghouse Elec. & Mfg. Co., Niagara Falls, N. Y.
Harriss, G. S., Hotel St. George, Brooklyn, N. Y.
Hartig, H. E., (Member), University of Minnesota, Minneapolis, Minn.
Heffernan, J. A., United Engineers & Constructors, Inc., Newark, N. J.
Hirst, J. I., (Member), Fittings Ltd., Oshawa, Ont., Can.
Hoag, M. L., Westinghouse Elec. & Mfg. Co., Salt Lake City, Utah
Holappa, G. A., Commonwealth Edison Co., Chicago, Ill.
Horton, W. S., Jr., 155 Linden St., New Haven, Conn.
Ide, G. W., Dist. No. 51 and No. 57, Medina, N. Y.
Johnson, F. E., Kuhlman Electric Co., Bay City, Mich.
Johnson, H. G., Railway & Industrial Engineering Co., Buffalo, N. Y.
Jones, E. E., (Member), Central Illinois Public Service Co., Springfield, Ill.
Jones, F., Commonwealth Edison Co., Chicago, Ill.
Kang, C. J., General Electric Co., Erie, Pa.
King, C. S., Great Western Power Co., Sacramento, Calif.
Kingsley, C., Jr., Mass. Institute of Technology, Cambridge, Mass.
Knapp, G. P., R. C. A. Photophone, Inc., Philadelphia, Pa.
Knight, E. H., Westinghouse Elec. & Mfg. Co., East Springfield, Mass.
Konicek, F., Western Electric Co., Baltimore, Md.
Kreuder, H. E., (Member), N. Y. & Queens Elec. Lt. & Pr. Co., Flushing, N. Y.
Kulman, F. E., New York Edison Co., New York, N. Y.
Lammli, W. T., Iowa Public Service Co., Cherokee, Iowa
Larson, O. C., Brooklyn Edison Co , Inc., Brooklyn, N. Y.
Leyland, S. C., Westinghouse Elec. & Mfg. Co., Newark, N. J.
Lilly, G. R., Electrical Research Products, Inc., Los Angeles, Calif.
Long, O. F., Fisher Lumber Corp., Memphis, Tenn.
(Applicant for re-election.)
Lydon, R. H., Burroughs & Lydon, Buffalo, N. Y.
MacLeod, D. R., General Electric Co., Erie, Pa.
Matthews, G. A., Detroit Edison Co., Detroit, Mich.
Maurer, K. L., (Member), American Tel. & Tel. Co., New York, N. Y.
McLeod, L. W., Westinghouse Elec. & Mfg. Co., San Antonio, Tex.
Messenger, T. I., Westinghouse Elec. & Mfg. Co., Buffalo, N. Y.
Miller, C. G., Schiefer Electric Co., Buffalo, N. Y.
Millsop, G. D., Northern States Power Co., Minneapolis, Minn.
Moore, R. D., General Electric Co., Schenectady, N. Y.
Morris, E. L., Westinghouse Elec. & Mfg. Co., Salt Lake City, Utah
Murphree, D. D., Central Power & Light Co., San Antonio, Tex.
Murrough, J. P., Nova Scotia Power Commission, Halifax, N. S., Can.
Nees, M., Westinghouse Electric Supply Co., Allentown, Pa.
O'Brien, R. P., Southern Pacific Co., West Alameda, Calif.
Oglesbee, W. A., Westinghouse Elec. & Mfg. Co., Sharon, Pa.
Oliver, J. H., General Electric Co., Philadelphia, Pa.
Osment, N. T., Saskatchewan Power Commission, Regina, Sask., Can.
Pawlicki, E., Defoe Boat & Motor Works, Bay City, Mich.
Peoples, J. L., Pacific Gas & Electric Co., San Francisco, Calif.
Peterson, R. A., General Railway Signal Co., Rochester, N. Y.
Pool, R. P., Public Service Co. of No. Illinois, Chicago, Ill.
Potter, R. E., Allis-Chalmers Mfg. Co., Detroit, Mich.
Proudfoot, A. A., Reliance Elec. & Engg. Co., Buffalo, N. Y.
Purdy, J. D., International Correspondence Schools, Scranton, Pa.
Ramsay, W. F., South African Dispatch Line, San Francisco, Calif.
Randall, H. L., Niagara Falls Power Co., Niagara Falls, N. Y.
Reinbold, R., (Member), Northern States Power Co., St. Paul, Minn.
Reynolds, H. L., Allis-Chalmers Mfg. Co., Dallas, Tex.
Reynolds, N. E., Chesapeake & Potomac Tel. Co., Baltimore, Md.
Rice, I. L., Rice Products, Inc., New York, N. Y.
Rich, C. S., American Institute of Elec. Engineers, New York, N. Y.
Rizer, C. K., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Robertson, J. A., Warren Telechron Co., Ashland, Mass.
Robinson, J. A., National Carbon Co., Inc., Chicago, Ill
Rodman, G. E., Commonwealth Edison Co., Chicago, Ill.
Rosenberg, L. T., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Schaffer, H. E., Westinghouse Elec. & Mfg. Co., Sharon, Pa.
Serett, H., A. B. See Elevators Co., Inc., Jersey City, N. J.
Shanley, J. V., New York Edison Co., New York, N. Y.
Shaw, R. C., Public Service Co. of No. Illinois, Maywood, Ill.
Shea, J. R., (Member), Western Electric Co., Kearny, N. J.
Siegfried, R. F., Clark, MacMullen & Riley, New York, N. Y.
Spencer, N. H., Allis-Chalmers Mfg. Co., Dallas, Tex.
Staley, M. R., General Electric Co., Schenectady, N. Y.
Stanton, R. E., (Member), Continental Oil Co., Denver, Colo.
Stelk, L., Commonwealth Edison Co., Chicago, Ill.
Strecker, G. M., (Member), Public Service Co. of Colorado, Fort Collins, Colo.
Taves, T. S., General Electric Co., Schenectady, N. Y.
Tisza, E. E., Wilson Welder & Metals Co., Hoboken, N. J.
Tucker, J. G., Commonwealth Edison Co., Chicago, Ill.
Vikoren, O. B., Philadelphia Electric Co., Philadelphia, Pa.
Vischer, A., Jr., (Member), Dow Jones & Co., New York, N. Y.
Wallace, J. H., Whelan Engineering Co., Washington, D. C.
Wallis, L. B., Holly Sugar Corp., Torrington, Wyo.
Watkins, T. B., L. A. Woolley, Inc., Buffalo, N. Y.
Watson, M. S., Public Service Co. of Northern Illinois, Chicago, Ill.
Wickham, W. H., Commonwealth Edison Co., Chicago, Ill.
Williams, J. H., D. L. & W. Railroad Co., Hoboken, N. J.
Wilson, F. H., San Antonio Public Service Co., San Antonio, Tex.
Winkler, E. W., University of North Carolina, Chapel Hill, N. C.
Wolf, A. P., (Member), Warren & Wetmore, New York, N. Y.
Zercher, S., Graybar Electric Co., Dallas, Tex.
Total 129

**Foreign**

Alexeef, A. E., Factory Elektrosila Works, Leningrad, U. S. S. R.
Anderson, B. S., English Electric Co., Ltd., Marunouchi, Tokyo, Japan
Gopalarao, K., Bezwada Municipality, Bezwada, India
Hvistendahl, H. S., (Member), Brown Boveri & Co., Ltd., Baden, Switzerland
Luther, R., Electric Factory, Electrosila, Leningrad, U. S. S. R.
McCandless, J., Ferranti, Ltd., Hollinwood, Lancs., Eng.
Total 6

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| No. 9—North West | G. E. Quinan, Box 1879, Seattle, Wash. | J. Hellenthal, Puget Sound Pr. & Lt. Co., Seattle, Wash. |
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**Dry Cell Tester.**—Bulletin, 2 pp. Describes type BME cell tester for ascertaining the condition of dry cells. Roller-Smith Company, 12 Park Place, New York.

**Watthour Meters.**—Catalog GEA 615, 32 pp. Describes G-E watthour meters. General Electric Company, Schenectady, N. Y.

**Megohmers.**—Bulletin, 12 pp. Describes the "Paragon Megohmer," a testing instrument for measuring insulation resistance of cables and other high tension equipment. Herman H Sticht & Co., 15 Park Row, New York.

**Arc Welding.**—Bulletins 12-13. These bulletins describe the latest developments in the arc welding field and contain notes of interest to users and designers of welding and welded products. Westinghouse Electric & Manufacturing Co., East Pittsburgh.

**Vitreous-Enameled Resistors.**—Bulletin GEA-1238, 20 pp. Describes G-E vitreous-enameled resistors, applicable for use in connection with radio apparatus, railway and fire alarm signals, telephone circuits, measuring instruments, etc. General Electric Company, Schenectady, N. Y.

**Ground Resistance Testing.**—Bulletin 1260, 64 pp. Covers measurement of the resistance to earth of ground connections, with special reference to the "Megger" ground tester. Illustrations and methods of tests are outlined. James G. Biddle, 1211 Arch Street, Philadelphia, Penna.

**Condensers, Resistances.**—Bulletins. Describe Polymet paper condensers for use in radio sets and other electrical devices requiring capacitors. Mica condensers are also described. Wire wound tubular resistances and variable resistances are the subject of other bulletins. Polymet Manufacturing Corp., 829 East 134th Street, New York.

**Industrial Control Equipment.**—Catalog GEA 606-B, 200 pp. Describes representative lines of industrial control; includes instructive matter on the care and operation of control devices; contains wiring diagrams, tables and other useful information. General Electric Company, Schenectady, N. Y.

**Matthews Fuswitches.**—Bulletin 507, 16 pp. Describes wet process, porcelain housed Matthews Fuswitches and disconnecting switches. Bulletin 506, 28 pp. Describes Fuswitches and disconnecting switches (open type). W. N. Matthews Corporation, 3706 Forest Park Boulevard, St. Louis, Mo.

**Oil Circuit Breakers.**—Bulletin 33, 32 pp. Describes Pacific Electric type JC oil circuit breakers, capacities from 11 kv. to 34.5 kv. Complete information is given on the controls, current transformers and auxiliary equipment together with construction data and wiring diagrams. The Pacific Electric & Manufacturing Corp., 5815 Third Street, San Francisco, Cal.

**Time Switches.**—Bulletin, 8 pp. Describes the new Sangamo electrically wound time-switch, now available for any commercial voltage and frequency. Motors for a-c. and d-c. are not interchangeable, but the only difference in the switches is in the motor itself. Losses are low, being under 2½ watts for either motor, and service results in clocks have shown the motors so dependable in every respect that they are unconditionally guaranteed when operated on proper circuits. Sangamo Electric Company, Springfield, Ill.

**Laboratory Vitreosil.**—Bulletin, 68 pp. Describes in detail the available data concerning fused silica and fused quartz and various applications already developed for these materials and suggesting further suitable uses. The bulletin is devoted chiefly to laboratory applications, but Vitreosil has many industrial uses in addition to its employment for research and analytical purposes. As an electrical insulator it is claimed to be superior to porcelain, mica and similar materials. Results of tests are contained in the bulletin. The Thermal Syndicate, Ltd., Schenectady and Atlantic Avenues, Brooklyn, N. Y.

**Potheads.**—Catalog 30. Describes a new line of G & W potheads in which interchangeability of parts has been obtained to a remarkable degree. By standardizing on bodies, entrances, lids, connectors, and porcelain, 3500 combinations are possible with comparatively few parts. The new potheads are even more definitely tight than previous models. The best wet process porcelain is used, and changes in petticoat design give higher flashover values. The catalog fully describes the new potheads and contains special bulletins on underground boxes, many types of switches and miscellaneous specialties. G & W Electric Specialty Company, 7780 Dante Avenue, Chicago, Ill.

## NOTES OF THE INDUSTRY

**Two Giant Generators for Brooklyn.**—The Brooklyn Edison Company has given an order to the General Electric Company for two turbine-generators, each of 160,000 kw. capacity, to be installed in the Hudson Avenue Station. The total cost of the generators, boilers and other necessary equipment will be $18,000,000. Both machines are expected to be in operation in 1931.

**Ward Leonard Acquires Burke Controller.**—Announcement has been made that the Ward Leonard Electric Company has taken over the Burke Controller Corporation and the factory will be moved to the Ward Leonard plant at Mount Vernon, N. Y., where the manufacture of the various Burke relays and control panels will be continued.

**American Transformer Company Expands Resistance Welding Line.**—Announcement has been made by the American Transformer Company, Newark, N. J., that expansion of its line of electric resistance welding machines is under way. E. P. Larkin, pioneer and authority in welding applications, is now associated with the company in charge of the expansion program. Efforts will be directed toward improvement in design and increasing the efficiency of welding operations in general.

**Higher Standards for "Copperweld."**—The Copperweld Steel Company, Glassport, Penna., has announced that the standard of tensile strength of Copperweld wires and strands has been raised. It is also made known that electric furnace steel has been adopted as standard for the manufacture of the steel core in all Copperweld wire, strand and ground rods. An increase of approximately fifty per cent in the strength of the product has been effected. New wire tables are now available and will be sent to interested readers upon request.

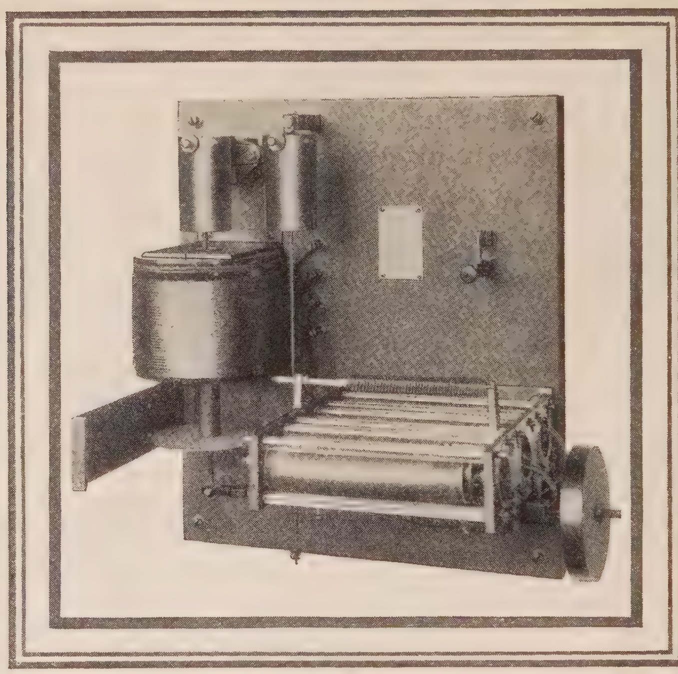
**New Dead-End Clamp.**—The Lapp Insulator Company, Inc., LeRoy, N. Y., has developed a light, strong and economical dead-end clamp for farm lines, distribution circuits, substation buses, etc. The clamp is of such design as to take care of the entire range of conductor sizes frequently used for this work, thereby making possible a great reduction in stock parts. The device is easily installed, has few parts to adjust, and is throughly reliable. In view of the economy necessary in construction of some lines the low price of the new clamp adapts it particularly for this purpose.

**Aerial Tramways for Passenger Transportation.**—A recent announcement made by the American Steel & Wire Company, 208 So. La Salle Street, Chicago, a subsidiary of the United States Steel Corporation, indicates that America will soon have at hand a means of travel hitherto largely confined to Europe. A successful and efficient system of aerial tramways for passenger transportation is now available, through the appointment of the above company as sole licensees of the Bleichert and Bleichert-Zuegg Systems in America.


KERITE INSULATED WIRE & CABLE CO

# OLD *in* *Principle*

# NEW *in Design*



Type AP-23 a-c. carbon-pile type voltage regulator (cover removed)

BASED upon the established principle that the resistance of a stack of carbon discs varies inversely as the pressure between them, Westinghouse recently designed the Carbon-pile Type Voltage Regulator for a-c. and d-c. generators.

This new regulator is extremely sensitive, has a high degree of accuracy in voltage regulation, and is quick-acting in restoring the voltage to normal. Means for anti-hunting are provided mechanically.

Furthermore, this type of regulator is particularly economical for the operation of small units. It requires practically no maintenance, because of the absence of contacts and the simplicity of both the lever system and the air dash-pots.

For complete information, call or write our nearest office.

*Service, prompt and efficient, by a coast-to-coast chain of well-equipped shops*

**Westinghouse**

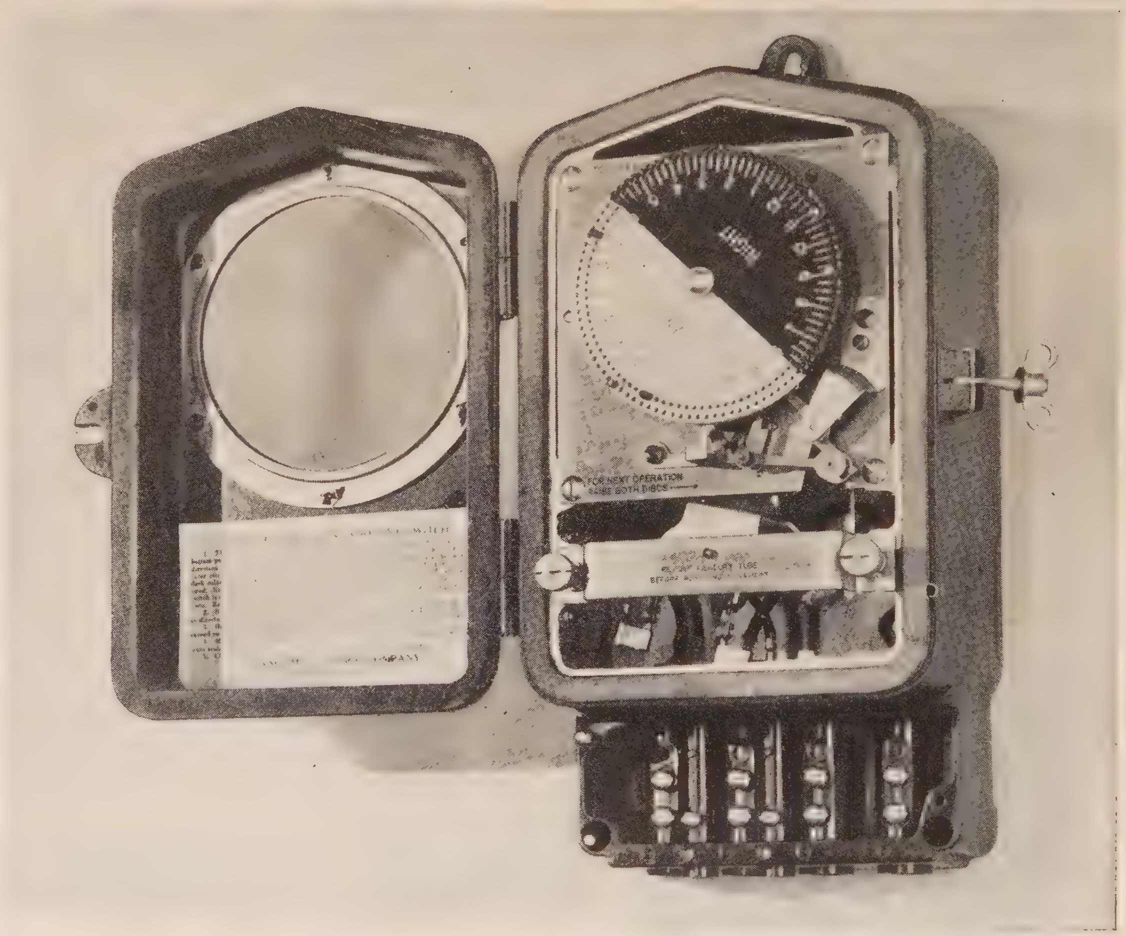
WESTINGHOUSE ELECTRIC

T 31310

TUNE IN THE WESTINGHOUSE SALUTE OVER THE N. B. C. NATION-WIDE NETWORK EVERY TUESDAY EVENING.

# Announcing the SANGAMO TIME-SWITCH

»»»»



High-lights of the
SANGAMO TIME-SWITCH

[1] The Hamilton-Sangamo standard clock, 7-jewel movement, insures accurate time-keeping.

[2] The Sangamo Time-switch will operate through current interruptions.

[3] It is independent of frequency or voltage variations.

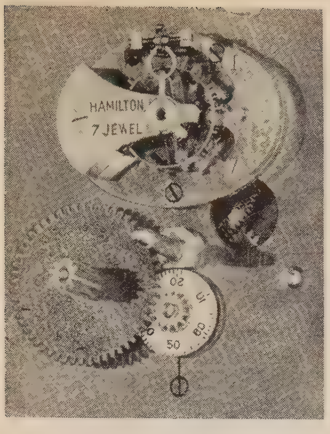
[4] It is made for either a. c. or d. c. operation.

[5] Low maintenance cost. Repairs, if necessary, are rapidly and economically effected.

[6] Reasonable first cost, due to volume production of motor and clock mechanism.

A LOGICAL OUTGROWTH OF THE SANGAMO ELECTRICALLY-WOUND CLOCK

86-8334-25




Close-up view of the escapement on the Sangamo Time-switch. Dust-cap removed to show movement and micrometer adjustment.

THE Sangamo Time-switch is essentially an electrically-wound Hamilton-Sangamo clock arranged to trip a mercury-tube switch. The base, as illustrated, has the same dimensions as a standard Sangamo 25-ampere type H.C. Meter and is fitted with removable terminals; a conduit-connected base will also be offered later. The dial is arranged to open and close the switch as often as every 15 minutes through a cycle of 24 hours.

Sangamo Time-switches are available for any commercial voltage and frequency, a. c. or d. c. The only difference between a. c. and d. c. is the motor. The losses are low . . . less than 2½ watts with either a.c. or d.c. motor.

The clock mechanism is a high-grade Hamilton-Sangamo standard movement, the mainspring being kept wound to a constant tension by a Sangamo noiseless motor. The escapement has seven jewels and is compensated for all variations in temperature. It is protected by a dust-cap and equipped with a micrometer fast or slow adjustment that can be operated without removing the dust-cap.

The switch mechanism is operated by the mainspring through a differential gear, so that if the motor is stopped due to current interruption, the spring will trip the switch when the proper time arrives.

For the purpose of setting the time intervals, the switch is equipped with a 24-hour dial, in the outer edge of which are two rows of holes . . . 96 in a row. Pins inserted in these holes open and close the switch . . . one row opens, and the other closes. The period of operation can be varied from one "open" and "close" in 24 hours to one every 15 minutes.

All working parts of the switch are readily accessible. The mercury tube can be removed from the front by unscrewing two knurled nuts. After removing the tube the clock mechanism proper can be removed from the front by taking out four screws. The motor and escapement may be removed as units from the clock mechanism. All parts are interchangeable, so that repairs, if necessary, can be rapidly and economically effected.

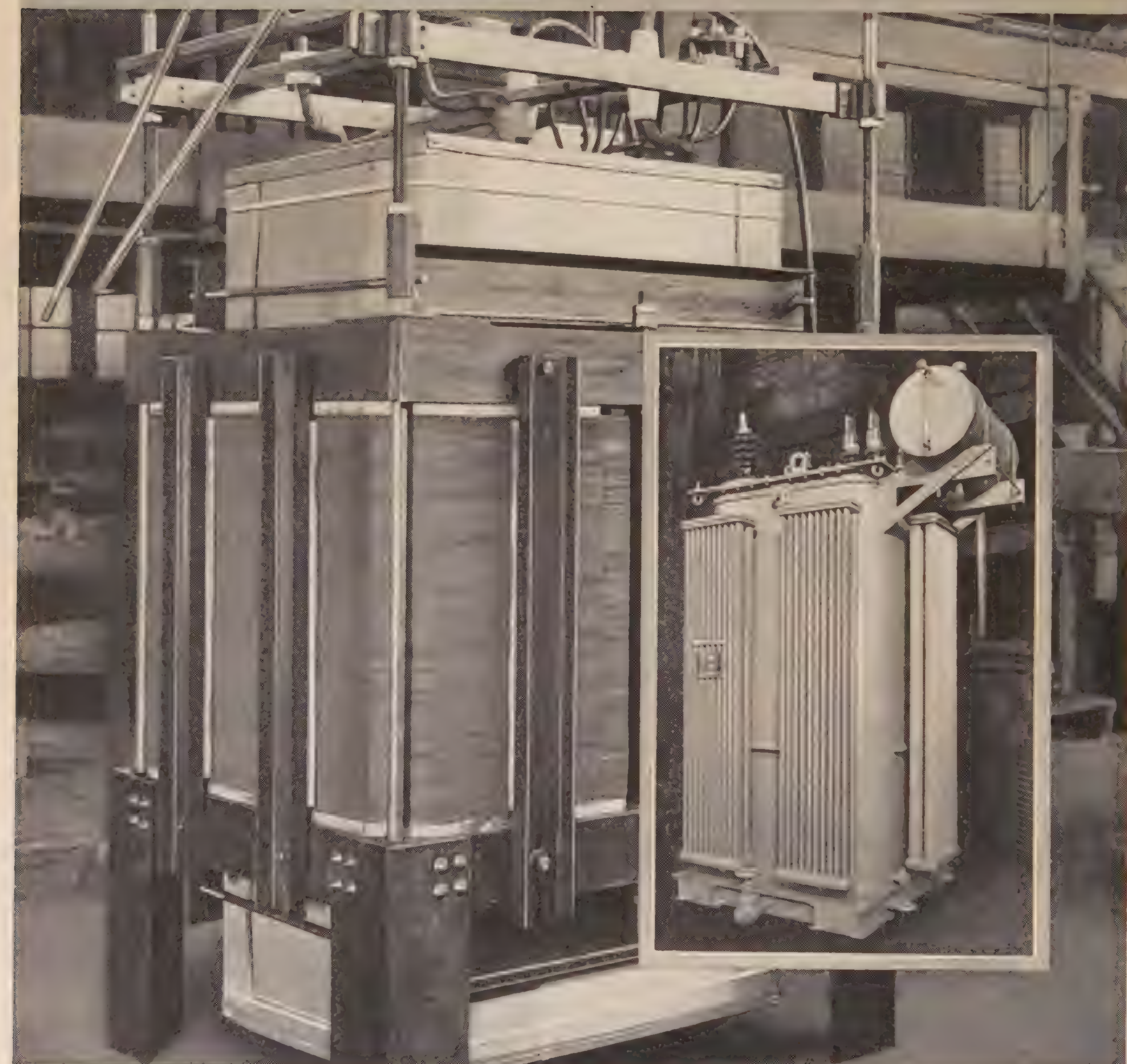
Volume production of Hamilton-Sangamo clock movements, employed in Sangamo Time-switches, means reduced costs and permits the switch to sell at a very moderate price. For instance, the list prices range from $40.00 for a single-pole, single-throw a. c. switch 115 or 230-volts, to $55.00 for a double-pole, double-throw, d. c. switch, 230-volts.

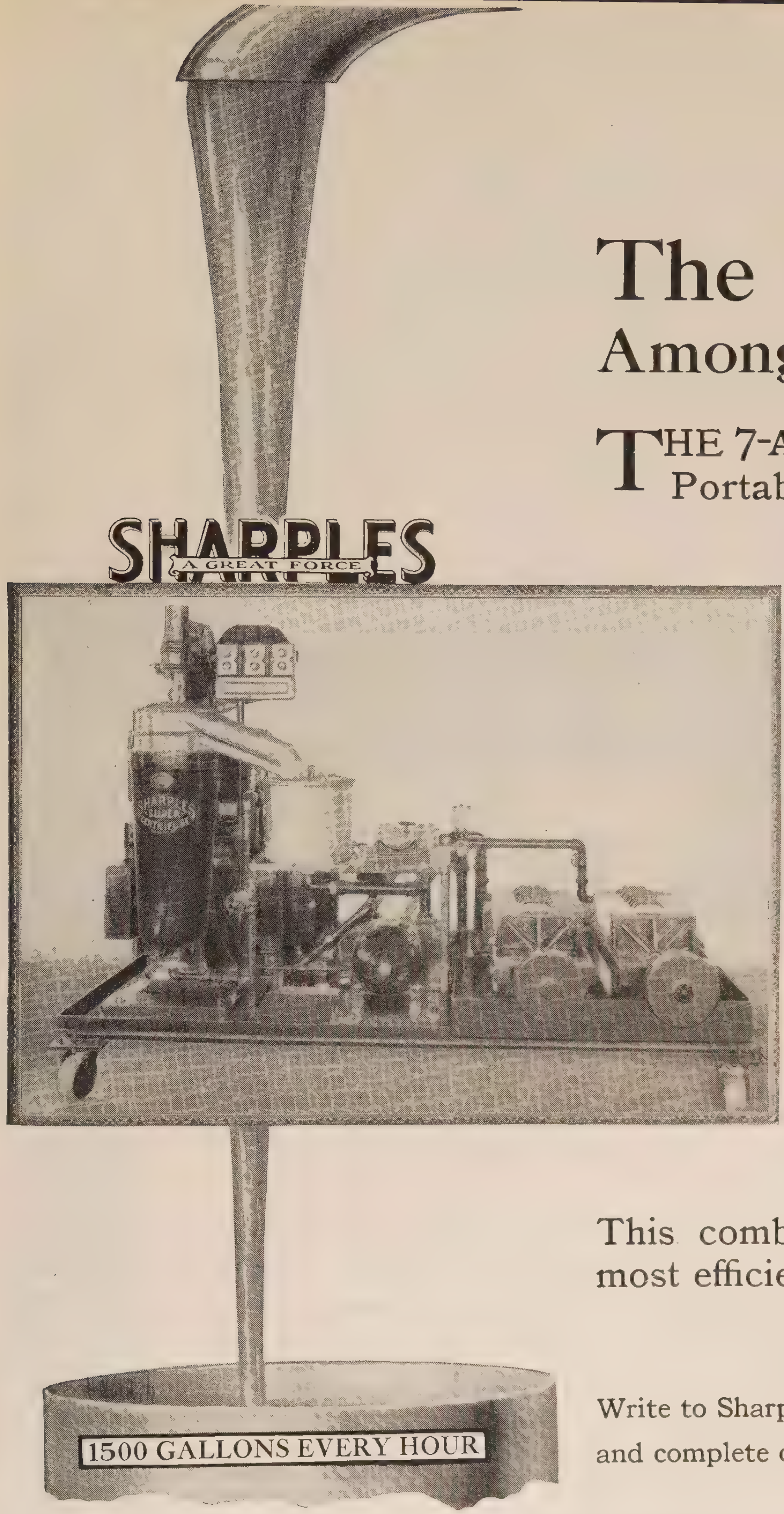
**SEND FOR LITERATURE** ««««

# SANGAMO

**ELECTRIC COMPANY**
**SPRINGFIELD, ILLINOIS**

-for High Voltage
or Low Voltage
in any Climate!
Always Dependable!
MINERALLAC
INSULATING
COMPOUNDS






# The Leader
## Among Oil Purifiers

THE 7-AB Sharples Combination Portable Centrifuge and Filter Press is characterized by the following advantages:

Thoroughly cleans 1500 gallons of oil per hour continuously.

Purification is complete in one operation. No storage tanks are necessary.

Operation is simple and clean. Practically no oil is lost in handling.

Construction is sturdy and simple. Maintenance is remarkably low.

Occupies very little floor space and can be easily moved from place to place.

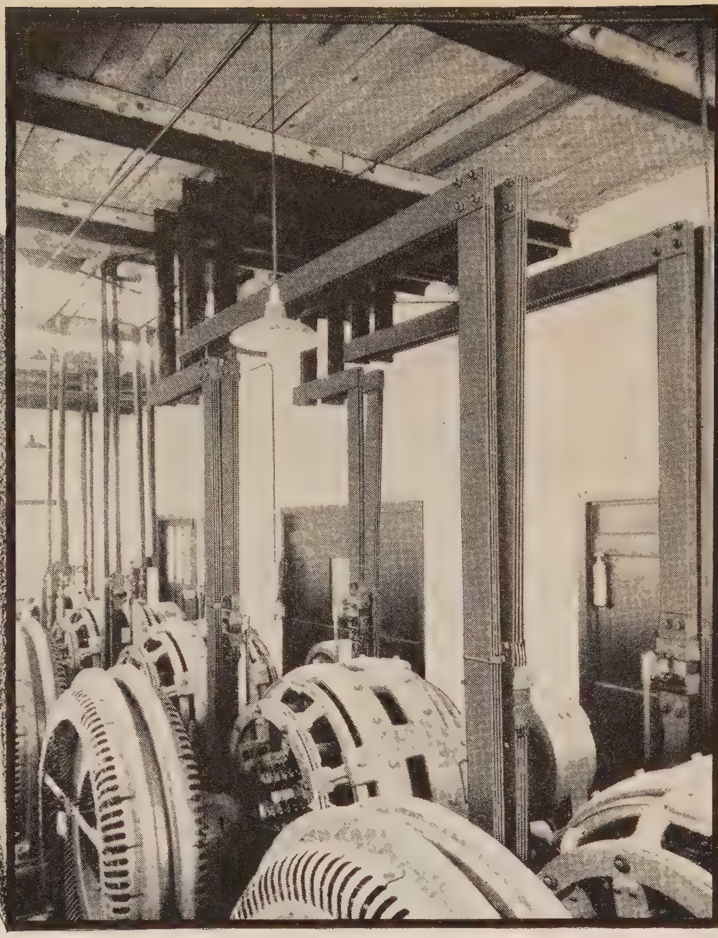
This combination is the latest and most efficient means of purifying oil.

* * *

Write to Sharples Engineers for technical bulletins and complete details.

THE SHARPLES SPECIALTY COMPANY, 2324 WESTMORELAND STREET, PHILADELPHIA
Boston, New York, Pittsburgh, Chicago, Detroit, Tulsa, San Francisco, Los Angeles, Toronto. Branch factories in England and France.

SHARPLES
A GREAT FORCE



# You can save 52% of the weight of all bus bars—and 35 cents on each dollar you must spend for them

Look at the Alcoa Aluminum Bus Bars in this motor-generator installation. There they stand, reaching up from floor to ceiling, without any intermediate support—rigid, light in weight, economical.

No wonder electrical men everywhere are turning to the use of bus bars of Alcoa Aluminum. Their use means longer spans, fewer joints, and a low maintenance cost. Low cost of installation, too, because, weighing 52% less than other metals commonly used for this purpose, yet providing the same current carrying capacity, their use calls for lighter supporting structures, and in some cases does away with the need of intermediate supporting structures entirely.

Other advantages of Alcoa Aluminum Bus Bars lie in the fact that the work of bending and assembling is accomplished with ease. Then too, these bars have lower operating temperatures.

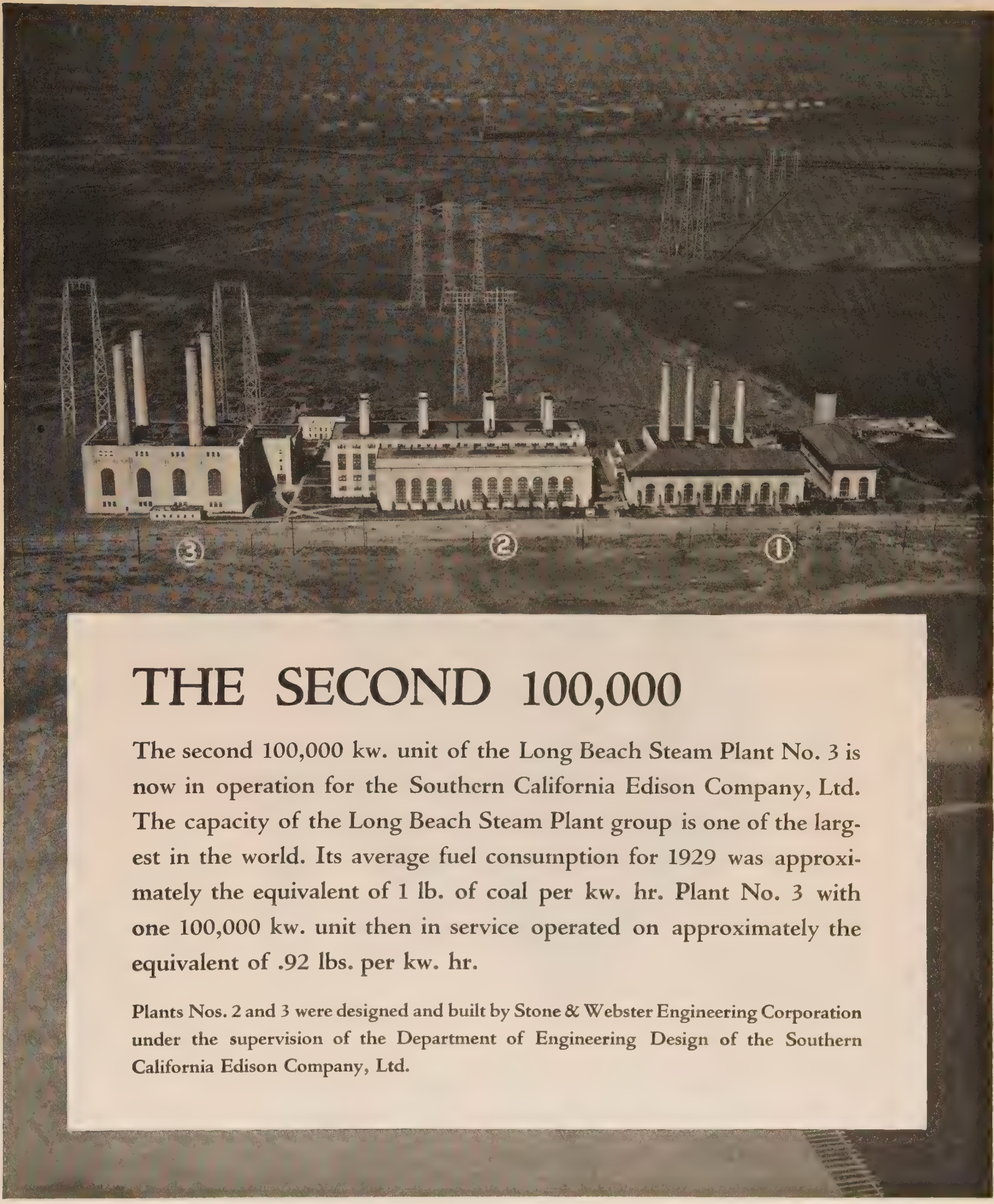
Tables of weights, carrying capacities and other technical data are contained in the booklet, "Aluminum Bus Bars". May we send you a copy? ALUMINUM COMPANY of AMERICA; 2448 Oliver Building, PITTSBURGH, PA.

ALCOA ALUMINUM

## BUS BARS MADE OF

# ALCOA ALUMINUM

BUILDERS and ENGINEERS for the BUSINESS LEADERS of AMERICA




# THE SECOND 100,000

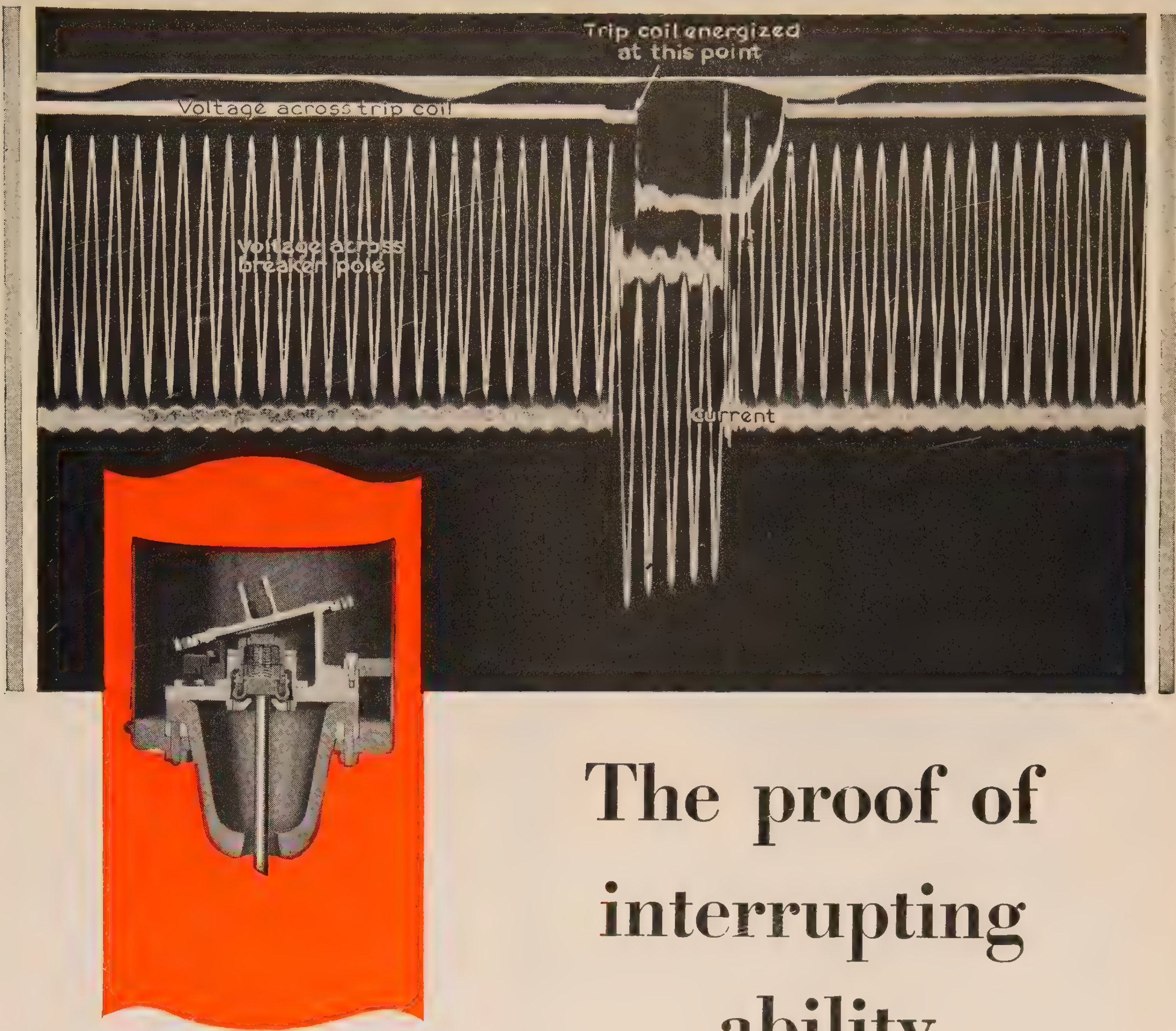
The second 100,000 kw. unit of the Long Beach Steam Plant No. 3 is now in operation for the Southern California Edison Company, Ltd. The capacity of the Long Beach Steam Plant group is one of the largest in the world. Its average fuel consumption for 1929 was approximately the equivalent of 1 lb. of coal per kw. hr. Plant No. 3 with one 100,000 kw. unit then in service operated on approximately the equivalent of .92 lbs. per kw. hr.

Plants Nos. 2 and 3 were designed and built by Stone & Webster Engineering Corporation under the supervision of the Department of Engineering Design of the Southern California Edison Company, Ltd.

## STONE & WEBSTER ENGINEERING CORPORATION

A SUBSIDIARY OF STONE & WEBSTER, INCORPORATED

# EXPLOSION-CHAMBER OIL CIRCUIT BREAKERS




## The proof of interrupting ability

SUPERIOR quality—quick clearing—unsurpassed interrupting ability—these are outstanding characteristics of explosion-chamber oil circuit breakers.

The oscillogram shows interrupting performance during an O-C-O operation on a 220-kv., 60-cycle system. The operation was completed in 4½ cycles of short circuit. Such performance proves the effectiveness of the explosion chamber.

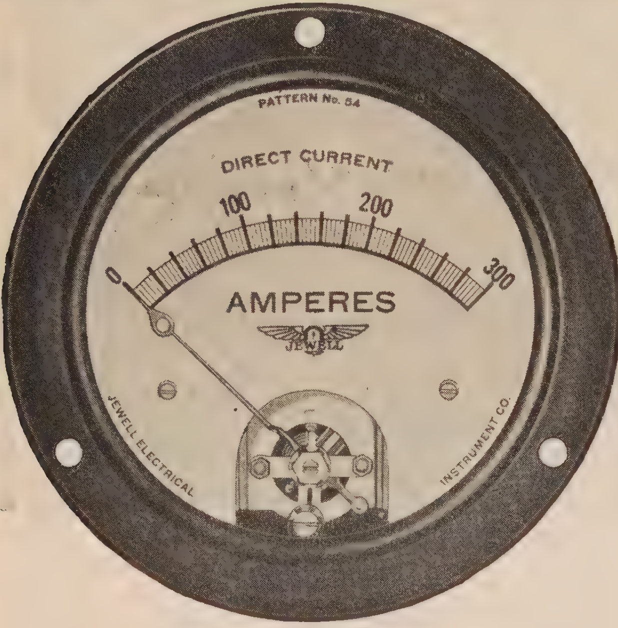
Arc confinement—short arcing time—consistent performance at varying currents—all these features together with small gas volume, the quick effectual cooling of gas, low tank pressure, slight oil deterioration, little contact burning, and many other advantages, explain the unexcelled interrupting ability of G-E explosion-chamber oil circuit breakers.

470-16

**GENERAL ELECTRIC**

SALES AND ENGINEERING SERVICE IN PRINCIPAL CITIES

# When Service is Most Severe JEWELL INSTRUMENTS LEAD!




ON arc welders, X-ray equipment, automotive test equipment, radio service apparatus — in fact wherever small instruments are used—Jewell Miniature Instruments have proved outstandingly successful, and the more difficult the service, the more dominating their lead.

Jewell Portable Instruments from laboratory precision standards to the Pattern 41 Pocket Portable and switchboard instruments ranging from 2 to 7 inches, present quality and utility unsurpassed.

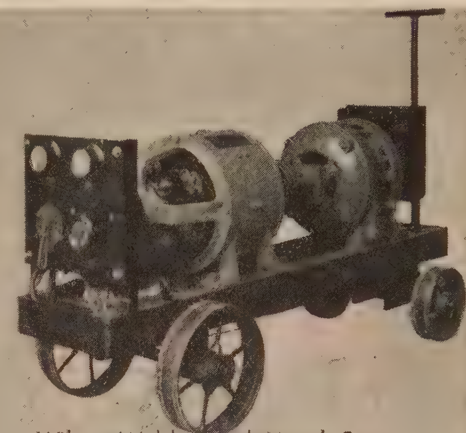
Whatever your instrument requirements, it will pay you to consult the nearest Jewell representative.

JEWELL ELECTRICAL INSTRUMENT CO.
1650 Walnut St., Chicago U.S.A.

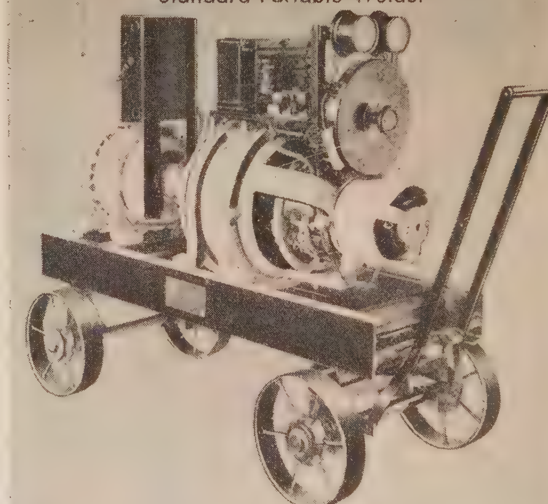
30 YEARS MAKING GOOD INSTRUMENTS

**JEWELL**

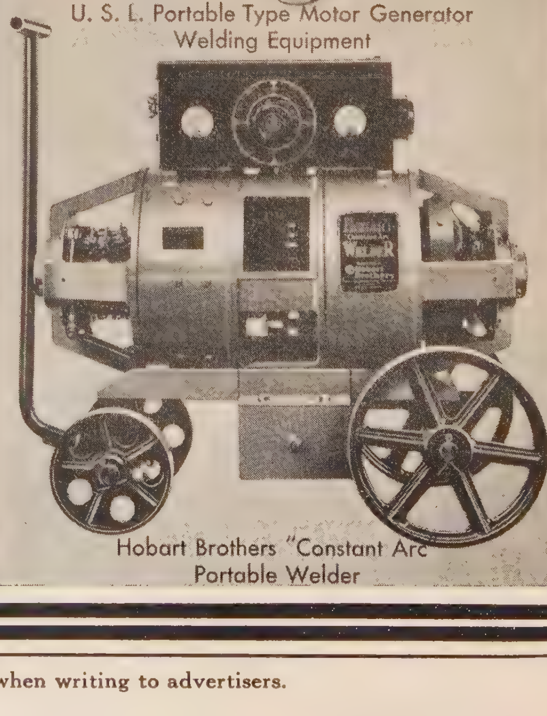
JEWELL



Wilson Welder and Metal Company Standard Portable Welder



U. S. L. Portable Type Motor Generator Welding Equipment



Hobart Brothers "Constant Arc" Portable Welder

SHUNT WOUND — BATTERY CHARGER

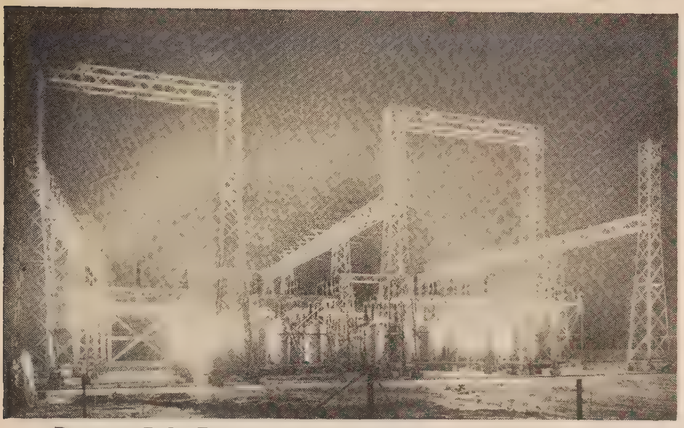
# THE DIVERTER POLE GENERATOR

ROCHESTER ELECTRIC PRODUCTS CORP. — PATENTED JAN. 1926 — ROCHESTER, N.Y. U.S.A.

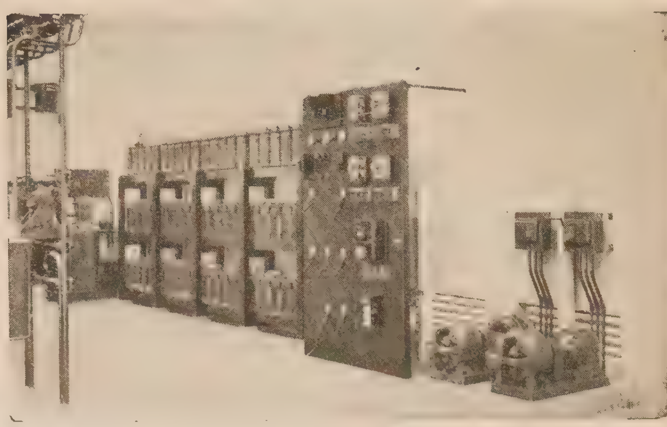
CONSTANT VOLTAGE INHERENT — RUNS AS MOTOR SAFELY

## FOR ALL KINDS OF BATTERY CHARGING—WITH SAFETY & ECONOMY

*ESPECIALLY ADAPTED TO FULL FLOATING*



**Diverter Pole Generator Sets are floating with both main control and supervisory control batteries at Leaside Substation, Hydro-Electric Commission of Ontario.**



**Diverter Pole Generator Sets installed in the Morgan-Hill Substation, Pacific Gas & Electric Co., San Francisco. The generator sets float with the oil switch battery.**

SINCE the above sets were installed, the Pacific Gas & Electric Company has installed or has on order

2 Diverter Pole Generator Sets—Station C, Sacramento
1 " " " " —Station C, San Francisco
1 " " " " —South Power House
2 " " " " —Station A, San Francisco
1 " " " " —West Point Substation
2 " " " " —Tiger Creek Power House
2 " " " " —Salt Springs Power House

The Hydro-Electric Commission has also placed a number of repeat orders since the installation at Leaside.

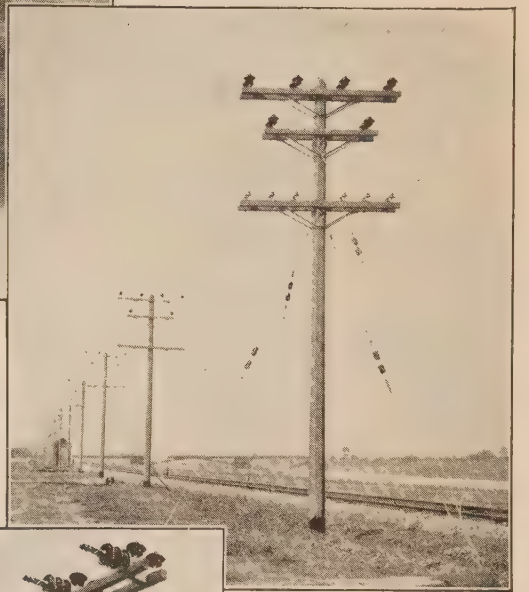
Over half of the sixty-five leading generating and distributing companies as listed in the May 3rd supplement of the Electrical World are now users of Diverter Pole Generators, and over sixty percent of them have placed more than one order. These repeat orders are the best evidence we can submit of the economy and satisfaction in using Diverter Pole Generators.

## ROCHESTER ELECTRIC PRODUCTS CORP.

87 ALLEN STREET ROCHESTER, N. Y.

BUILDERS OF D. C. MOTORS AND GENERATORS FOR 30 YEARS

*Opening the gates of Lock No. 8, at Port Colborne for the first time on September 16, 1929.*



*(Above) The 22-kv. transmission paralleling the canal. O-B multi-part pin type insulators No.11622 and O-B one piece pin type insulators No. 12847 are shown.*

# The Welland Ship Canal—

## An Important Link of a 2339-Mile Deep-waterway to the Atlantic

IN 1829, just 100 years ago, the first Welland Canal was constructed. At that period in the commercial history of the Great Lakes, this canal, with its forty locks and eight feet of water, served well. But, as lake commerce developed, and as lake freighters grew in size and draft, this narrow, shallow channel could not serve. So in 1850 the canal was enlarged and deepened. In 1870 the depth was increased to 12 feet, with locks 240 feet long, and in 1887 the depth was again increased to 14 feet.

In 1901 the tonnage through Welland Canal was 620,000 tons. In 1914 it had increased to 3,860,000 tons, and in 1927 a new maximum of 7,247,459 tons was established.

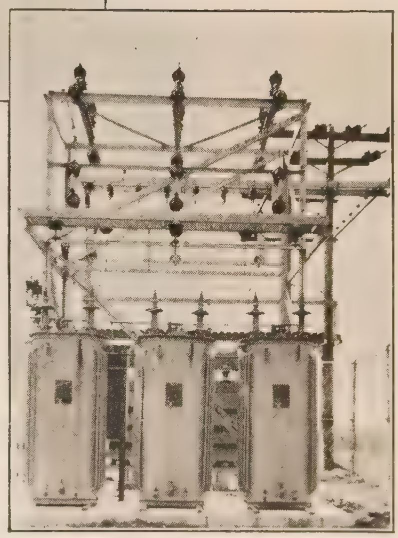
Work on the Welland Ship Canal started in 1913. On September 16, 1929, the Canadian Steamship Lines S. S. Meaford broke the silk ribbon across Lock Eight—the longest lock in the world—and steamed from the waters of Lake Erie into the new Canal.

Eight huge locks, each with a lift of 46½ feet and with a usable length of 820 feet and a width of 80 feet, lift the huge freighters from the 243 foot level of Lake Ontario to the 568 foot level of Lake Erie. Eight hours are consumed in the 25-mile passage.

A 22-kv. transmission line parallels the new canal from Port Colborne, on Lake Erie to Port Weller, the new artificial harbor at the Lake Ontario terminal of the canal. Substations serve the various locks. For the insulation of this transmission line, O-B pin type insulators, suspension insulators and transformer bushings were used extensively.

Here again, as in the past, Canada has taken a great step forward in the development of water traffic between the great lakes ports and the Atlantic seaboard. Ohio Brass Company, Mansfield, Ohio. In Canada, Canadian Ohio Brass Company, Limited, Niagara Falls, Canada.

*Strain tower on transmission line paralleling the Welland Ship Canal. O B suspension insulators No. 25622, O-B multipart pin type insulators No. 11622 and O-B one-piece pin type insulators No. 12847 are shown.*



*Bushings on the Packard transformers used for this substation are O-B No. 26082.*

1246H

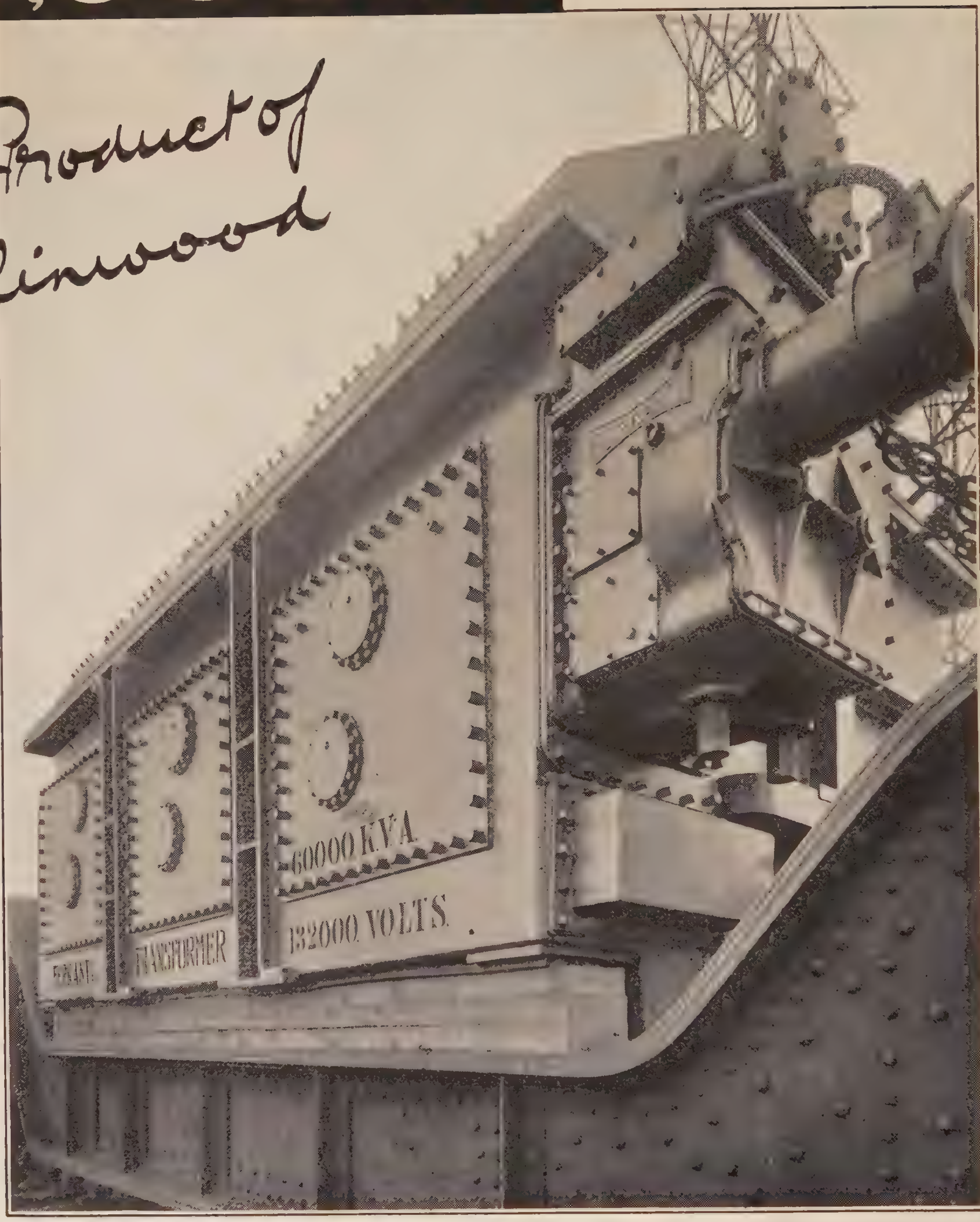
# Ohio Brass Co.

PORCELAIN INSULATORS
LINE MATERIALS
RAIL BONDS
CAR EQUIPMENT
MINING MATERIALS
VALVES

NEW YORK PHILADELPHIA PITTSBURGH BOSTON CHICAGO CLEVELAND ST. LOUIS ATLANTA DALLAS LOS ANGELES SAN FRANCISCO SEATTLE

# 60,000 KVA.

*The Product of Hollinwood*

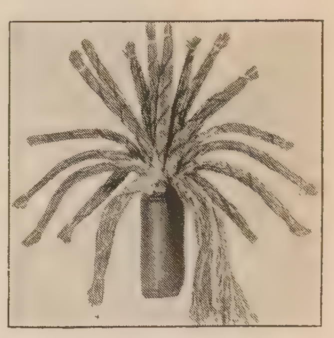



**Arrival on site of the Largest Transformer for S.E. England**

**FERRANTI, LTD.**
**HOLLINWOOD**
**ENGLAND**

**3 PHASE UNIT 132 KV**
**On Load Tap Changing**
**50% Output without Forced Cooling**
**Within Railway Loading Gauge**

# FERRANTI

*1818 conversations at one time* can be carried on through this new type cable. It contains 3636 insulated wires within a diameter of 2⅝ ins.

*The flying telephone laboratory* in which Western Electric airplane telephone equipment has been developed by the Bell Laboratories. Provision for communication between ground and plane marks a great forward step in flying.

*One of the 18 materials in your telephone* is rubber from the plantations of Sumatra. Western Electric goes to market in every corner of the world.

# In *fair weather or foul . . .*

## Western Electric backs up your telephone service

In foul weather, just as in fair, Western Electric backs up the Bell System with all the apparatus and supplies needed to restore, maintain or expand your telephone service.

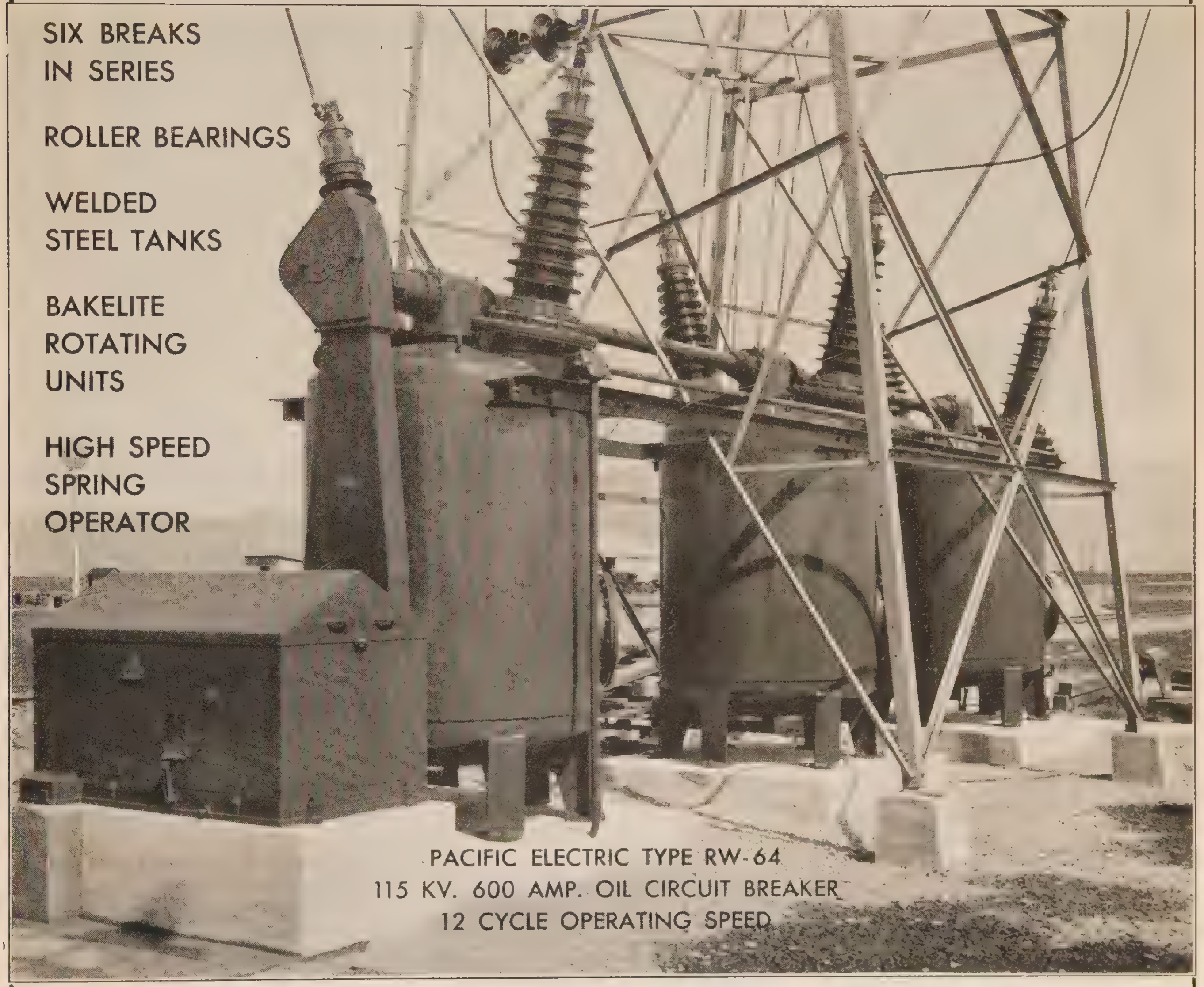
This Company manufactures telephone equipment of every sort, with a skill acquired through 50 years' experience. At 32 warehouses it holds great reserves of telephone material available for shipment day or night. It delivers and installs the apparatus when and where needed.

The large scale manufacture of standardized equipment, too, is an economy. So is the concentrated purchasing—a responsibility that Western Electric undertakes for the telephone companies of the Bell System. All in all, here is a work of mass production, purchasing and distribution which for size and complexity has no parallel in industry.

**Western Electric**

MAKERS
OF YOUR
TELEPHONE

# PACIFIC ELECTRIC MULTIPLE BREAK OIL CIRCUIT BREAKERS



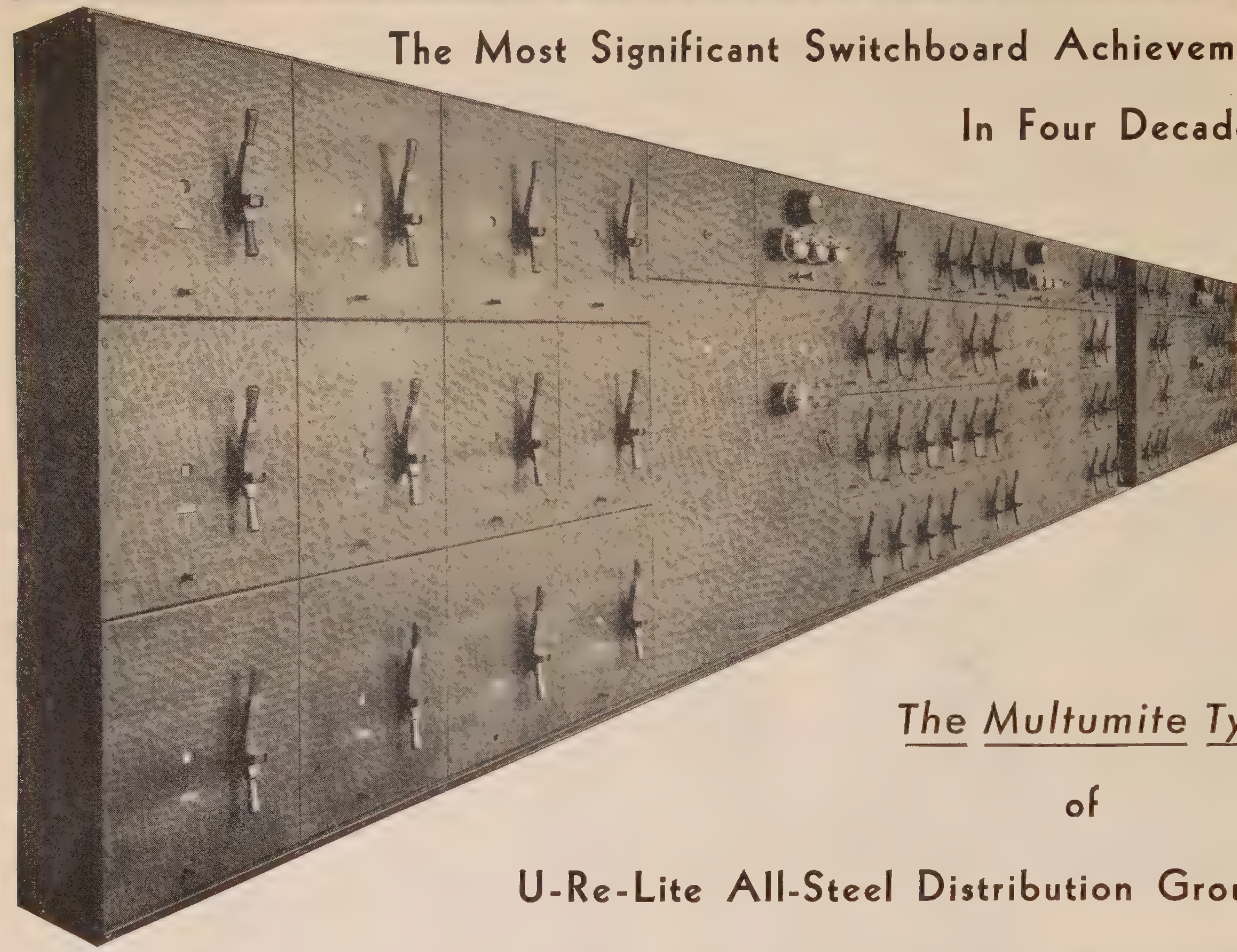

## Pacific Electric Manufacturing Corp.

Bay View, San Francisco, Cal. Dunes Highway, Gary, Indiana

30 Church St., New York City
Allen Building, Dallas, Texas
H. W. Hellman Bldg., Los Angeles, Cal.
Liggett Building, Seattle, Wash.
Public Service Bldg., Tulsa, Okla.

1700 Sansom St., Philadelphia, Pa.
Dwight Building, Kansas City, Mo.
Symes Building, Denver, Colo.
Plymouth Bldg., Minneapolis, Minn.
P. O. Box 263, Phoenix, Ariz.
Bedell Building, Portland, Ore.

# The Most Significant Switchboard Achievement In Four Decades!



## The Multumite Type of U-Re-Lite All-Steel Distribution Groups

Forty years ago, open switchboards consisted of switches, circuit breakers and meters, mounted on marble. Open switchboards today are practically the same, using slate instead of marble and with refinements in switches, circuit breakers and meters.

The Multumite type of U-Re-Lite All-Steel Distribution Groups, therefore, marks a real achievement in switchboard improvement.

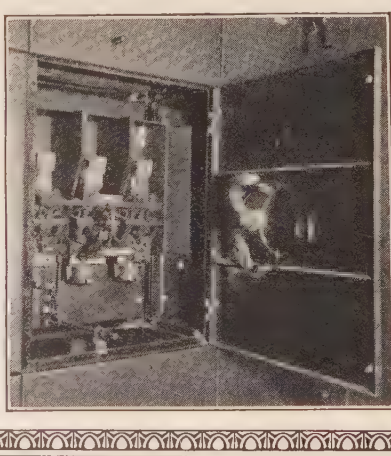
The Multumite group combines these significant advantages:—

1. *Utmost Safety to Operators*—every live part, including buses, enclosed in steel—circuit breakers operated by insulated external U-Re-Lite handles and non-closable against overload or short circuit.

2. *Protection and Control*—positive overload and short circuit protection and time delay for lighting circuits—across-the-line starting of motors, combined with overload and short circuit protection.

3. *Rupturing Capacity*—U-Re-Lites with the new Min-Arc-Ite (minimum arc) barriers have higher rupturing capacities at 550 volts A.C. and under than any protective equipment of a like nature.

4. *Space Saving*—in less than one-third the length of an open switchboard, this group protects three 2500 ampere main circuits, with automatic transfer from normal to emergency source; 66 feeder circuits ranging from 200 amperes to 1250 amperes each; and provides for 14 future feeders.



5. *Easy Accessibility*—to inspect the circuit breakers it is only necessary to open the hinged doors.

6. *Double Disconnects*—any feeder circuit breaker can be disconnected from the line and the load, easily and safely by means of disconnecting contacts on the rear of the circuit breaker panels (Hingite construction).

7. *Minimum Field Work*—these groups are shipped complete, can be inspected before shipment and the only field work required is bolting to floor channels, making main bus connections and running in feeder cables.

8. *Flexibility*—provision for future feeders can be made in present groups, or future groups can be added any time.

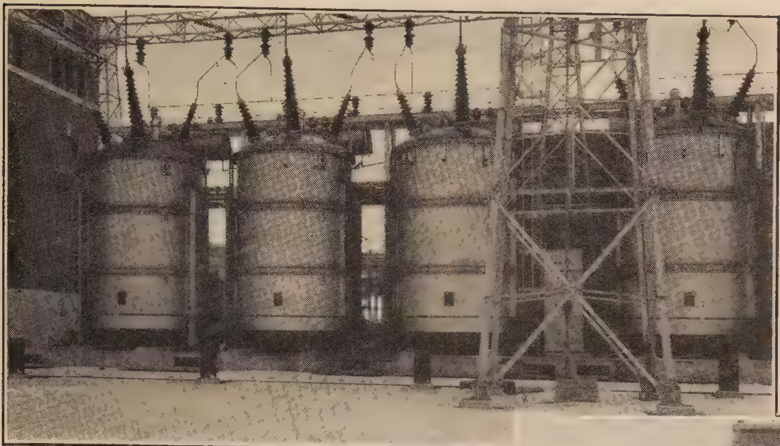
9. *Appearance*—the black Duco finish, the flush fronts and backs, and the uniform height of these groups add to the workmanlike appearance of any modern power plant.

It will pay you to study the application of a Multumite group to your switchboard requirements—get in touch with the nearest I-T-E representative.

I-T-E CIRCUIT BREAKER COMPANY
19th and Hamilton Sts., Philadelphia

Birmingham, Boston, Buffalo, Chicago, Cincinnati, Cleveland, Dallas, Denver, Detroit, Duluth, Kansas City, Los Angeles, Minneapolis, Montreal, New Orleans, New York, Omaha, Philadelphia, Pittsburgh, St. Louis, San Francisco, Seattle, Toronto, Vancouver, Winnipeg.

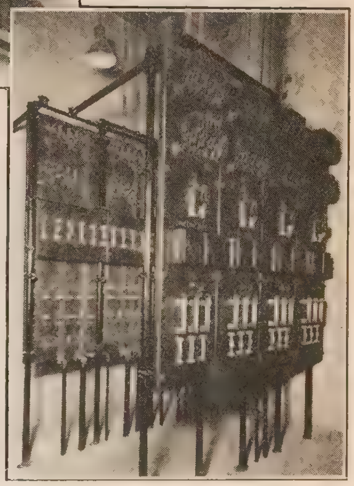
# A. I. E. E. SUMMER CONVENTION, JUNE 23rd-27th



Leaside Station of Hydro Electric Power Commission of Ontario, where there are installed 7 Westinghouse single phase, 15,000 Kv-a., 220/110 13.2 Kv., three winding, 25 cycle, O. I. W. C. Transformers.

*The Canadian Westinghouse Company invite delegates to inspect the works at Hamilton, Ont.*

11 of the bridges over Welland Canal have been equipped by Westinghouse with the latest type of electro-magnetic control.



One of the control panels for a bridge at the Welland Canal.

Toronto is the center of a district containing a large number of electrical installations. Being at the junction of a vast tie-in between the Niagara System and the Gatineau System (over 200 miles away) exponents of long distance transmission of hydro-electric power will be gratified by a visit to the Leaside Station of Hydro Electric Power Commission of Ontario. A unique installation of outdoor vertical synchronous condensers awaits their inspection here.

In the planned visit of convention visitors to the new Welland Canal, the latest types of electromagnetic control of bridges will be seen.

**CANADIAN WESTINGHOUSE COMPANY LIMITED**

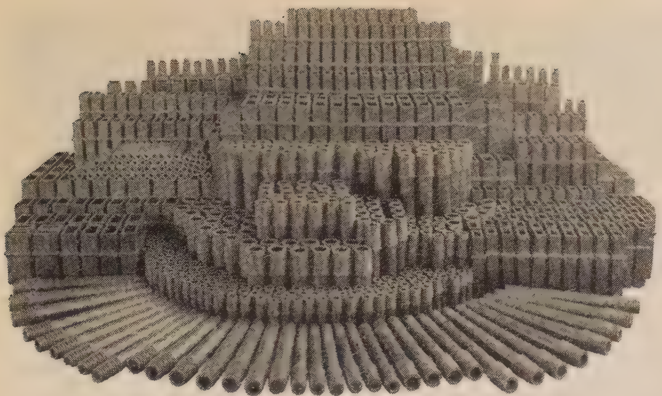
**TORONTO OFFICE - METROPOLITAN BLDG.**

HEAD OFFICE AND WORKS - HAMILTON, ONTARIO

CANADIAN WESTINGHOUSE

# Westinghouse

5030



# BURKE

## *Wall* and *Floor* Entrance Bushings

***run straight and uniformly true to size***

Embodying electrical and mechanical qualities which make them particularly well suited as insulators, BURKE wall and floor entrance bushings run straight and uniformly true to size.

BURKELECT, of which the bushings are made, is formed in steel molds under enormous pressure. The process insures a homogeneous product, exceptionally free from defects.

BURKELECT of itself will not sustain combustion. Carbonized surfaces resulting from power arcs may be cleaned and the insulation thus restored to original value. It is not affected by hot oil and is non-hygroscopic.

**HIGH TENSION EQUIPMENT**

- BUS BAR CLAMPS
- CABLE CLAMPS
- TERMINAL LUGS
- LEAF TERMINALS
- END CONNECTORS
- BRACING CLAMPS
- CONNECTORS
- JUNCTION BOXES
- EXPANSION JOINTS
- MOULDED INSULATION
- TERMINAL BLOCKS

BURKE HIGH TENSION EQUIPMENT meets the needs of Public Service Companies, in every respect. Practical engineers, experienced in Central Station Operation design the High Tension Copper Connectors and Moulded Insulation which BURKE manfactures in stock designs.

# BURKE

**ELECTRIC COMPANY**

**ERIE, PA.**

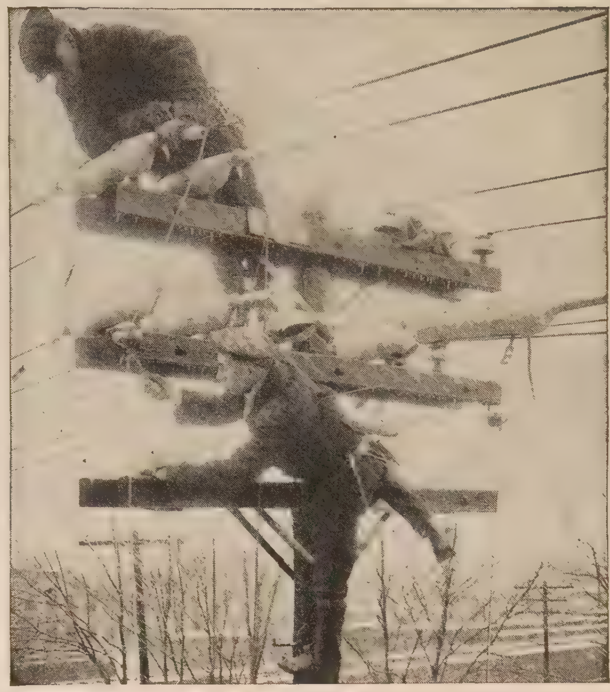
***offices in principal cities***

MANUFACTURERS OF

ALTERNATING AND DIRECT CURRENT MOTORS AND GENERATORS, MOTOR GENERATOR SETS, ARC WELDING EQUIPMENT, UNIVERSAL MOTORS, COPPER CONNECTORS, MOULDED BURKELECT INSULATORS, CONTROLEAD TERMINAL BLOCKS

# MARSHALL'S

## LINEMEN'S SHIELDS



# *A Safeguard That Pays . . .*

Linemen have confidence in Marshall Shields—they use them—depend on them for protection on hot wire work.

They are made of pure rubber, amply thick and are easily applied—tested to 30,000 volts and sturdily built.

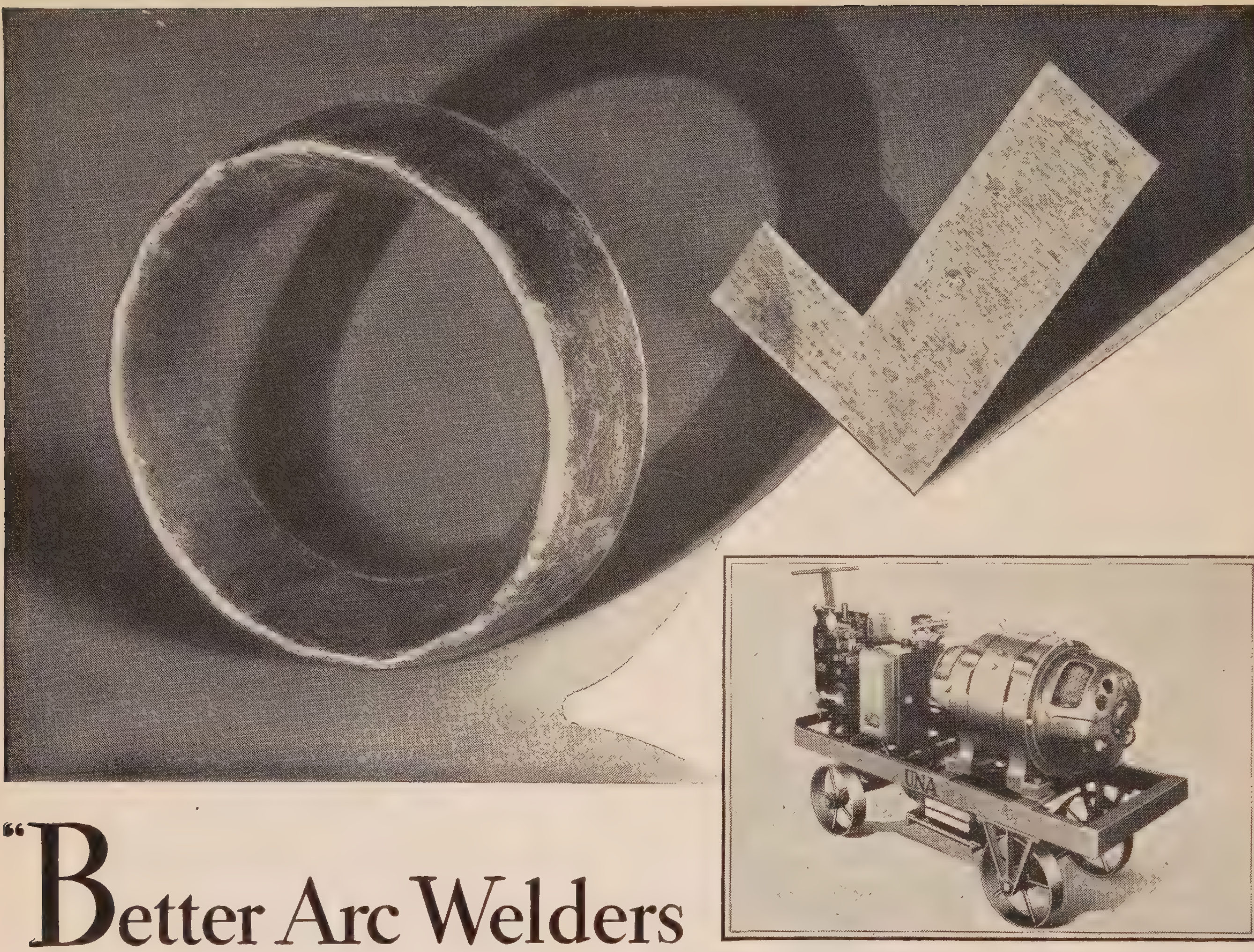
It pays to furnish your line crew with Marshall's "Pigs." It's not only protection for your men but their reasonable cost comes back many times in the time they save.

*Write us for complete information.*

**LINEMEN PROTECTOR CO.**

2008 Penobscot Building

DETROIT MICHIGAN




# "Better Arc Welders are made with Super Micanite"

HERE insulation is one of the most vital factors in performance. Only the best will do. That's why Una Arc Welder commutators are insulated with Super-Micanite.

Super-Micanite contributes unfailingly to the results for which the machine is designed and built. Higher dielectric strength . . . greater surface resistivity . . . the absence of injurious decomposition products, and the fact that Super-Micanite does not carbonize makes it unique among built-up mica insulations.

If you have never tried Super-Micanite send for a sample. Subject it to the most rigorous tests. Then we feel certain you will agree that it is the outstanding electric insulation of its kind.

MICA INSULATOR COMPANY

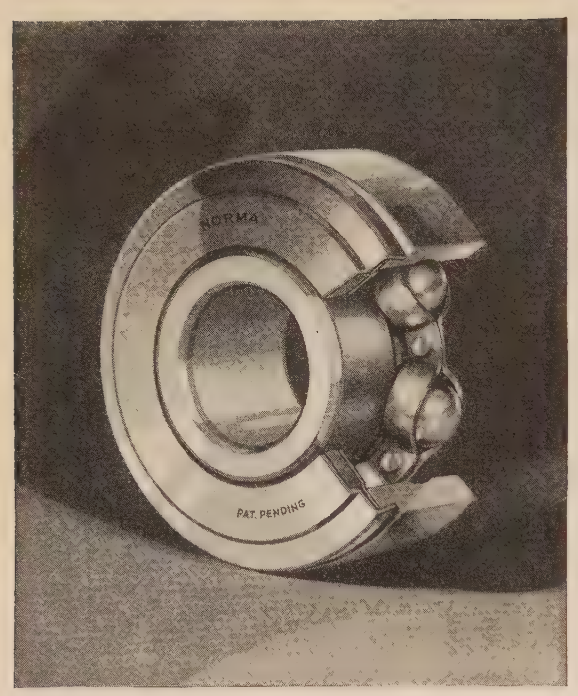
New York: 200 Varick St. Chicago: 542 So. Dearborn St.
Cleveland Pittsburgh Cincinnati San Francisco Seattle
Birmingham Los Angeles Montreal and Toronto, Canada
Works: Schenectady, N. Y. London, England

PERFECT MICANITE INSULATOR REG. U.S PAT. OFF.

Electrical INSULATION

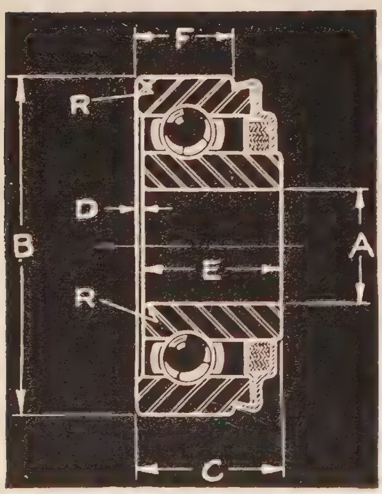
PERFECT EMPIRE INSULATOR REG. U.S. PAT. OFF.

MICA INSULATION OILED CLOTH INSULATION




# Another "PRECISION" Bearing

# "GREASEAL"




*Write for the "Greaseal" Data Sheets, showing details of application*

## BALL BEARING

### *A Notably Better Bearing*
### *With Distinctive Economic Advantages*

A self-contained, self-sealed, grease-packed, dirt-proof bearing with a larger grease capacity, ready for years of service without renewal of lubricant.

Needs only the most simple and inexpensive mounting, with the very minimum of machining and assembling cost.

AN ALL-STEEL BEARING, WITH A SOLID, ONE-PIECE OUTER RING.

| Bearing Number | Bore "A" M. M. | Bore "A" Inches | O. Dia. "B" M. M. | O. Dia. "B" Inches | Width "C" Inches | Offset "D" Inches | Length "E" Inches | Width "F" Inches | RAD. "R" M. M. | RAD. "R" Inches |
|---|---|---|---|---|---|---|---|---|---|---|
| GS-96 | 6 | .2362 | 19 | .7480 | .3543 | .016 | .3383 | .2362 | 1 | .039 |
| GS-97 | 7 | .2756 | 22 | .8661 | .4060 | .016 | .3900 | .2756 | 1 | .039 |
| GS-98 | 8 | .3150 | 22 | .8661 | .4060 | .016 | .3900 | .2756 | 1 | .039 |
| GS-98246 | 6 | .2362 | 24 | .9449 | .4060 | .016 | .3900 | .2756 | 1 | .039 |
| GS-98247 | 7 | .2756 | 24 | .9449 | .4060 | .016 | .3900 | .2756 | 1 | .039 |
| GS-9824 | 8 | .3150 | 24 | .9449 | .4060 | .016 | .3900 | .2756 | 1 | .039 |
| GS-99 | 9 | .3543 | 26 | 1.0236 | .4527 | .016 | .4367 | .3150 | 1 | .039 |
| GS-200 | 10 | .3937 | 30 | 1.1811 | .5118 | .016 | .4958 | .3543 | 1 | .039 |
| GS-201 | 12 | .4724 | 32 | 1.2598 | .5512 | .016 | .5352 | .3937 | 1 | .039 |
| GS-202 | 15 | .5905 | 35 | 1.3780 | .5905 | .016 | .5745 | .4330 | 1 | .039 |
| GS-203 | 17 | .6693 | 40 | 1.5748 | .6693 | .016 | .6533 | .4724 | 1 | .039 |
| GS-204 | 20 | .7874 | 47 | 1.8504 | .7480 | .016 | .7320 | .5512 | 1 | .039 |
| GS-205 | 25 | .9843 | 52 | 2.0472 | .7874 | .016 | .7714 | .5906 | 1 | .039 |

**NORMA-HOFFMANN BEARINGS CORPORATION STAMFORD, CONN., U.S.A.**

NB-1567

# 1500 YEARS AGO

## TAPPING WAS A MODERN ASSEMBLY OPERATION

*This golden arm band of the fifth century was joined by a machine screw which fitted into a female thread cut by a tap.*

# TODAY IT IS OUT OF DATE

## FOR HUNDREDS OF ASSEMBLIES

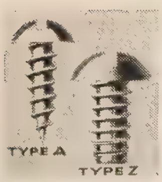
Today the metal working industry has the advantage of a revolutionary improvement. Modern genius has produced unique Screws, so threaded and hardened that they tap their own thread in metal as they are driven. Slow and expensive tapping, for 1500 years necessary to the assembly of metal products with screws, is no longer required for many assemblies.

American industry has been quick to adopt these Self-tapping Screws in place of machine screws. Without sacrificing security of the fastenings more than 50,000 plants have eliminated costly tapping operations and other assembly difficulties through the use of Self-tapping Screws. In the production of almost every kind of electrical product . . . from an attachment plug to a power house panel board . . . these unique Screws are affecting great economies. Savings of thousands of dollars a year are common.

Thousands of wise production heads and designers now try Self-tapping Screws *first* for metal assemblies. You, too, will find it a profitable practice. Check up on your fastening jobs, now. Send a brief description of assemblies for which the Screws may be suitable. We will furnish proper samples for a thorough test.

PARKER-KALON CORPORATION
198 Varick Street, New York, N. Y.

### THESE UNIQUE SCREWS ELIMINATE TAPPING



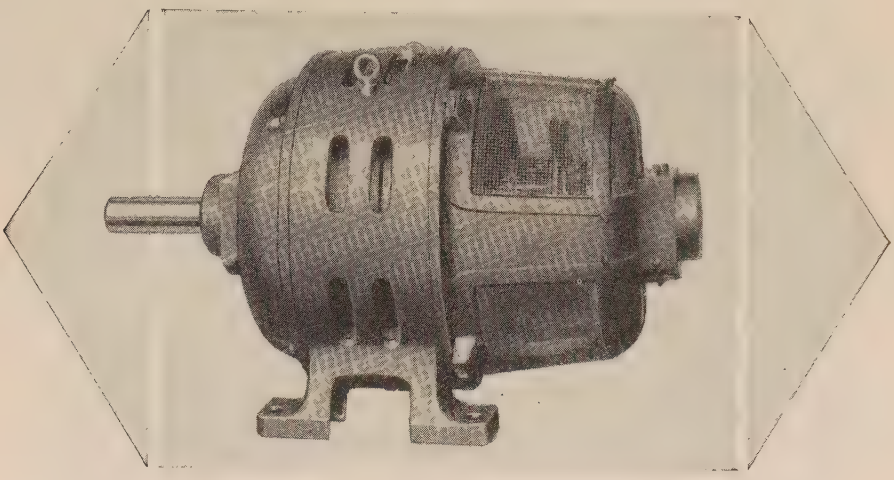

**Hardened Sheet Metal Screws**
For joining sheet metal and making fastenings to sheet metal, aluminum and die castings, Bakelite, etc. Turn Screw into drilled or pierced hole. It taps a thread in the metal. Holds as well as a machine screw

**Hardened Metallic Drive Screws**
For making permanent fastenings to iron, brass and aluminum castings, steel, Bakelite, etc. Hammer Screw into a drilled or formed hole. It taps a thread in the material, making a better fastening than machine screws.

# PARKER-KALON
# SELF-TAPPING SCREWS

*Patented in United States and Foreign Countries*

THEY KEEP A-RUNNING



*10 Horse Power Century Type SR Slip Ring Induction 3 and 2 Phase Motor*

# FOR STARTING EXCEPTIONALLY HEAVY LOADS

Wherever starting conditions are especially severe or where speed reduction is desirable, Century Type SR Slip Ring Induction 3 and 2 Phase Motors are particularly recommended...When equipped with speed control, their speed can be varied down to one-half of their normal or maximum ratings.

These motors are well balanced in design—no one characteristic is over developed at the expense of another ...The shafts are liberally proportioned...The bearings last—they are made of phosphor bronze, the best bearing material obtainable...Enclosing covers can be furnished in screen, grided, drip proof, fully enclosed or dust proof types.

Built in standard sizes from ¼ to 15 horse power.

CENTURY ELECTRIC COMPANY
1806 PINE ST. , , ST. LOUIS, MO.

*40 U. S. and Canadian Stock Points and More Than 75 Outside Thereof*

SINGLE PHASE, THREE PHASE, AND DIRECT CURRENT MOTORS

Century MOTORS

MOTOR GENERATOR SETS, ROTARY CONVERTORS, FANS AND VENTILATORS

614A

FOR MORE THAN 26 YEARS AT ST. LOUIS

# Classified Advertiser's Index for Buyers

**Manufacturers and agents for machinery and supplies used in the electrical and allied industries.**

**Note: For reference to the advertisements see the Alphabetical List of Advertisers on page 58.**

AIR COMPRESSORS
- Allis-Chalmers Mfg. Co., Milwaukee
- General Electric Co., Schenectady
- Western Electric Co., All Principal Cities

AMMETER COMPENSATING COILS
- Minerallac Electric Co., Chicago

AMMETER, VOLTMETERS
- (See INSTRUMENTS, ELECTRICAL)

ANCHORS, GUY
- Copperweld Steel Co., Glassport, Pa.
- Kearney Corp., Jas. R., St. Louis
- Matthews Corp., W. N., St. Louis

BATTERY CHARGING APPARATUS
- Electric Specialty Co., Stamford, Conn.
- General Electric Co., Schenectady
- Rochester Electric Products Corp., Rochester, N. Y.
- Wagner Electric Corp., St. Louis
- Western Electric Co., All Principal Cities
- Westinghouse Elec. & Mfg. Co., E. Pittsburgh

BEARINGS, BALL
- Norma-Hoffmann Bearings Corp., Stamford, Conn.

BOXES, FUSE
- Bull Dog Electric Products Co., Detroit
- General Electric Co., Schenectady
- Kearney Corp., Jas. R., St. Louis
- Metropolitan Device Corp., Brooklyn, N. Y.
- Western Electric Co., All Principal Cities
- Westinghouse Elec. & Mfg. Co., E. Pittsburgh

BOXES, JUNCTION
- Burke Electric Co., Erie, Pa.
- G & W Elec. Specialty Co., Chicago
- Metropolitan Device Corp., Brooklyn, N. Y.
- Standard Underground Cable Co., Pittsburgh

BRUSHES, COMMUTATOR

*Carbon*
- Morganite Brush Co., Inc., L. I. City, N. Y.
- National Carbon Co., Inc., Cleveland
- Westinghouse Elec. & Mfg. Co., E. Pittsburgh

*Copper Graphite*
- Morganite Brush Co., Inc., L. I. City, N. Y.
- National Carbon Co., Inc., Cleveland
- Westinghouse Elec. & Mfg. Co., E. Pittsburgh

BUS BARS, ALUMINUM
- Aluminum Co. of America, Pittsburgh

BUS BAR FITTINGS
- Burke Electric Co., Erie, Pa.
- Burndy Engineering Co., Inc., New York
- Delta-Star Electric Co., Chicago
- General Electric Co., Schenectady
- Memco Engg. & Mfg. Co., L. I. City, N. Y.
- Ohio Brass Co., Mansfield, O.
- Westinghouse Elec. & Mfg. Co., E. Pittsburgh

BUSHINGS, PORCELAIN
- Ohio Brass Co., Mansfield, O.

CABLE ACCESSORIES
- Burke Electric Co., Erie, Pa.
- Delta-Star Electric Co., Chicago
- Dossert & Co., New York
- G & W Electric Specialty Co., Chicago
- General Electric Co., Schenectady
- Minerallac Electric Co., Chicago
- Standard Underground Cable Co., Pittsburgh
- Western Electric Co., All Principal Cities

CABLE RACKS
- Metropolitan Device Corp., Brooklyn, N. Y.

CABLES
- SEE WIRES AND CABLES

CABLEWAYS
- American Steel & Wire Co., Chicago
- Roebling's Sons Co., John A., Trenton, N. J.

CASTINGS, ALUMINUM
- Aluminum Co. of America, Pittsburgh

CIRCUIT BREAKERS

*Air—Enclosed*
- Condit Elec. Mfg. Corp., Boston
- I-T-E Circuit Breaker Co., The, Philadelphia
- Roller-Smith Co., New York
- Western Electric Co., All Principal Cities

*Oil*
- Condit Electrical Mfg. Corp., Boston
- General Electric Co., Schenectady
- Pacific Electric Mfg. Corp., San Francisco
- Roller-Smith Co., New York
- Westinghouse Elec. & Mfg. Co., E. Pittsburgh

CLAMPS, GUY & CABLE
- Burke Electric Co., Erie, Pa.
- Burndy Engineering Co., Inc., New York
- Kearney Corp., Jas. R., St. Louis
- Matthews Corp., W. N., St. Louis

CLAMPS, INSULATOR
- Memco Engg. & Mfg. Co., L. I. City, N. Y.

COILS, CHOKE
- Burke Electric Co., Erie, Pa.
- General Electric Co., Schenectady
- Kearney Corp., Jas. R., St. Louis
- Memco Engg. & Mfg. Co., L. I. City, N. Y.
- Westinghouse Elec. & Mfg. Co., E. Pittsburgh

COILS, MAGNET
- Belden Mfg. Co., Chicago
- General Electric Co., Schenectady
- Westinghouse Elec. & Mfg. Co., E. Pittsburgh

COMMUTATOR SEGMENTS AND RINGS
- Mica Insulator Co., New York

CONDENSATION PRODUCTS
- Bakelite Corporation, New York

CONDENSERS, RADIO
- General Radio Co., Cambridge, Mass.
- Sangamo Electric Co., Springfield, Ill.

CONDENSERS, STEAM
- Allis-Chalmers Mfg. Co., Milwaukee
- General Electric Co., Schenectady
- Westinghouse Elec. & Mfg. Co., E. Pittsburgh

CONDUIT, UNDERGROUND FIBRE
- Western Electric Co., All Principal Cities

CONNECTORS, SOLDERLESS
- Burke Electric Co., Erie, Pa.
- Dossert & Co., New York
- Kearney Corp., Jas. R., St. Louis
- Westinghouse Elec. & Mfg. Co., E. Pittsburgh

CONNECTORS AND TERMINALS
- Belden Mfg. Co., Chicago
- Burke Electric Co., Erie, Pa.
- Burndy Engineering Co., Inc., New York
- Dossert & Co., New York
- G & W Electric Specialty Co., Chicago
- Western Electric Co., All Principal Cities
- Westinghouse Elec. & Mfg. Co., E. Pittsburgh

CONTACTS, TUNGSTEN
- General Electric Co., Schenectady

CONTROLLERS
- Electric Controller & Mfg. Co., Cleveland
- General Electric Co., Schenectady
- Rowan Controller Co., Baltimore, Md.
- Westinghouse Elec. & Mfg. Co., E. Pittsburgh

CONVERTERS—SYNCHRONOUS
- Allis-Chalmers Mfg. Co., Milwaukee
- Electric Specialty Co., Stamford, Conn.
- Wagner Electric Corp., St. Louis
- Westinghouse Elec. & Mfg. Co., E. Pittsburgh

COPPER CLAD WIRE
- Belden Mfg. Co., Chicago
- Western Electric Co., All Principal Cities

COPPERWELD WIRE
- Copperweld Steel Co., Glassport, Pa.
- Standard Underground Cable Co., Perth Amboy, N. J.

CUT-OUTS
- Bull Dog Electric Products Co., Detroit
- Condit Electrical Mfg. Corp., S. Boston
- General Electric Co., Schenectady
- G & W Electric Specialty Co., Chicago
- Kearney Corp., Jas. R., St. Louis
- Metropolitan Device Corp., Brooklyn, N. Y.
- Wagner Electric Corp., St. Louis
- Westinghouse Elec. & Mfg. Co., E. Pittsburgh

DIVERTER POLE GENERATORS
- Rochester Electric Products Corp., Rochester, N. Y.

DYNAMOS
- (See GENERATORS AND MOTORS)

DYNAMOTORS
- Burke Electric Co., Erie, Pa.
- Electric Specialty Co., Stamford, Conn.
- Rochester Electric Products Corp., Rochester, N. Y.

ELECTRIFICATION SUPPLIES, STEAM ROAD
- General Electric Co., Schenectady
- Ohio Brass Co., Mansfield, Ohio
- Westinghouse Elec. & Mfg. Co., E. Pittsburgh

ENGINEERS, CONSULTING AND CONTRACTING
- (See PROFESSIONAL ENGINEERING DIRECTORY)

ENGINES

*Gas & Gasoline*
- Allis-Chalmers Mfg. Co., Milwaukee

*Oil*
- Allis-Chalmers Mfg. Co., Milwaukee

*Steam*
- Allis-Chalmers Mfg. Co., Milwaukee

EXPERIMENTAL WORK
- Manufacturers' and Inventors' Electric Co. New York

FANS, MOTOR
- Century Electric Co., St. Louis
- General Electric Co., Schenectady
- Wagner Electric Corp., St. Louis
- Westinghouse Elec. & Mfg. Co., E. Pittsburgh

FLOW METERS
- General Electric Co., Schenectady

FURNACES, ELECTRIC
- General Electric Co., Schenectady
- Westinghouse Elec. & Mfg. Co., E. Pittsburgh

FUSES

*Enclosed Refillable*
- General Electric Co., Schenectady
- Westinghouse Elec. & Mfg. Co., E. Pittsburgh

*Enclosed Non-Refillable*
- General Electric Co., Schenectady

*Open Link*
- General Electric Co., Schenectady
- Metropolitan Device Corp., Brooklyn, N. Y.

*High-Tension*
- Delta-Star Electric Co., Chicago
- Metropolitan Device Corp., Brooklyn, N. Y.

FUSE MOUNTINGS
- Memco Engg. & Mfg. Co., L. I. City, N. Y.

FUSE PULLERS
- Kearney Corp., Jas. R., St. Louis

# Classified Advertiser's Index for Buyers—*Continued*

# 70 kv

The Laboratories at Corning are gratified indeed by the enthusiastic reception accorded the 70 kv. Pyrex Power Insulator.

In this one-piece insulator, weighing but 36 pounds, engineers have seen the answer to expressed wishes.

The *inherent* characteristics of this insulator preclude porosity and deterioration.

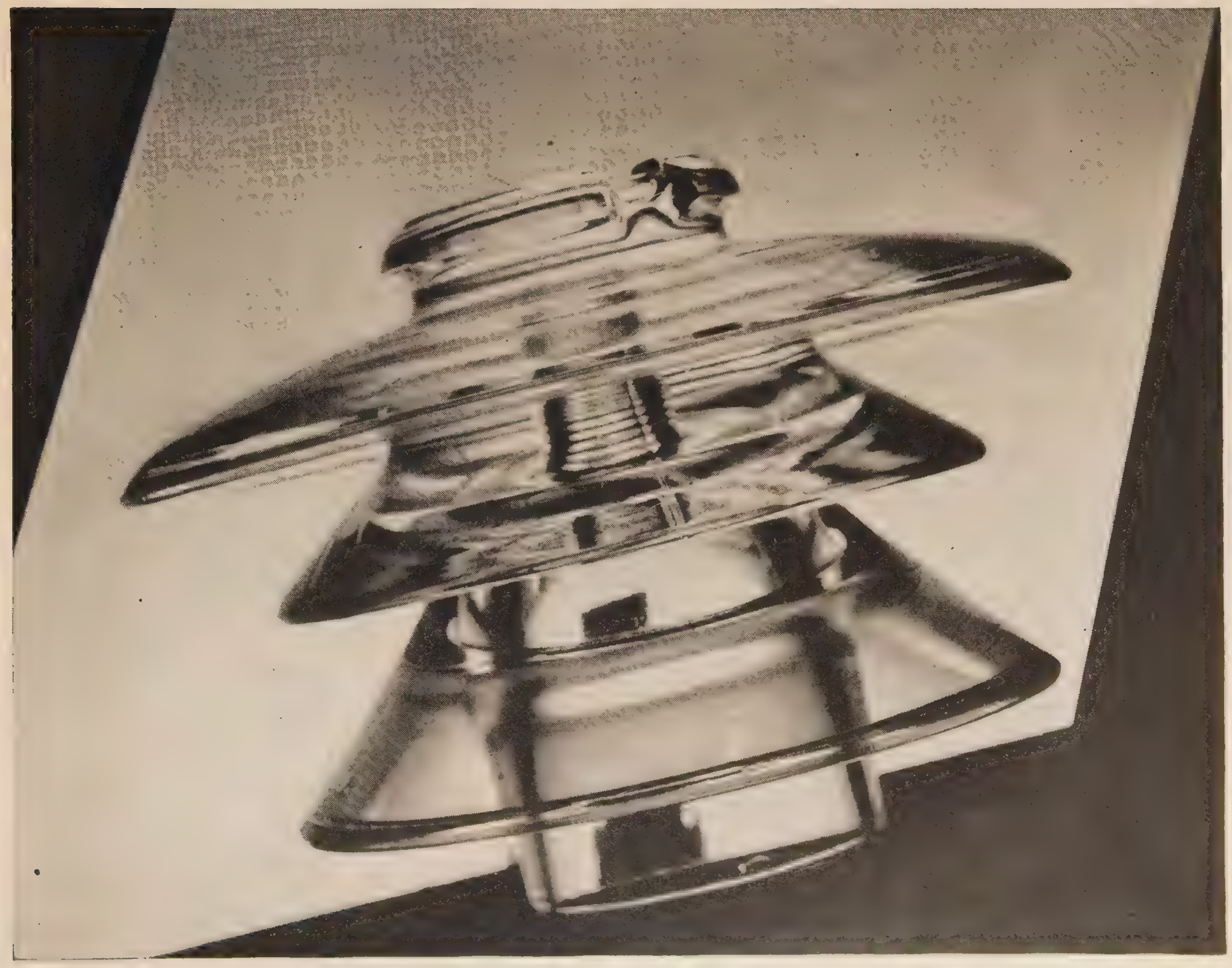
The *inherent* characteristics provide its resistance to power arcs and lightning impulse voltages.

*An exclusive feature is the elimination of corona and brush discharges with their attending disturbances.*

When such unusually large strides are made in any product, they are rarely the result of product refinement. A new principle or new material (the result of scientific research) is usually the influencing factor.

The advantages of the Pyrex* Power Insulator are due to the *material* from which it is made.

*T. M. Reg. U. S. Pat. Off.



AN ACHIEVEMENT OF CORNING GLASS WORKS, CORNING, N. Y.

# Classified Advertiser's Index for Buyers—*Continued*

**ROPE, WIRE**
American Steel & Wire Co., Chicago
Roebling's Sons Co., John A., Trenton, N. J.

**SCREWS**
*Drive Hardened Metallic*
Parker-Kalon Corp., New York
*Self-Tapping Hardened*
Parker-Kalon Corp., New York
*Sheet Metal, Hardened Self-Tapping*
Parker-Kalon Corp., New York

**SEARCHLIGHTS**
General Electric Co., Schenectady
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

**SLEEVE TWISTERS**
Kearney Corp., Jas. R., St. Louis

**SLEEVES, SPLICING**
Memco Engg. & Mfg. Co., L. I. City, N. Y.

**SOCKETS AND RECEPTACLES**
General Electric Co., Schenectady
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

**SOLENOIDS**
Belden Mfg. Co., Chicago
Electric Controller & Mfg. Co., Cleveland
General Electric Co., Schenectady
Roebling's Sons Co., John A., Trenton, N. J.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

**SPRINGS**
American Steel & Wire Co., Chicago

**STARTERS, MOTORS**
Condit Electrical Mfg. Corp., Boston
Electric Controller & Mfg. Co., Cleveland
General Electric Co., Schenectady
Roller-Smith Co., New York
Rowan Controller Co., Baltimore, Md.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

**STOKERS, MECHANICAL**
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

**STOP-WATCHES**
Meylan, A. R. & J. E., New York

**SUB-STATIONS**
American Bridge Co., New York
General Electric Co., Schenectady
Memco Engg. & Mfg. Co., L. I. City, N. Y.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

**SWITCHBOARDS**
Allis-Chalmers Mfg. Co., Milwaukee
Bull Dog Electric Products Co., Detroit
Condit Electrical Mfg. Corp., Boston
General Electric Co., Schenectady
Metropolitan Device Corp., Brooklyn, N. Y.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

**SWITCHES**
*Automatic Time*
General Electric Co., Schenectady
Minerallac Electric Co., Chicago
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
*Disconnecting*
Bull Dog Electric Products Co., Detroit
Burke Electric Co., Erie, Pa.
Condit Electrical Mfg. Corp., Boston
Delta-Star Electric Co., Chicago
General Electric Co., Schenectady
Kearney Corp., Jas. R., St. Louis
Matthews Corp., W. N., St. Louis
Memco Engg. & Mfg. Co., L. I. City, N. Y.
Pacific Elec. Mfg. Corp., San Francisco
Roller-Smith Co., New York
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
*Fuse*
Bull Dog Electric Products Co., Detroit
General Electric Co., Schenectady
Kearney Corp., Jas. R., St. Louis
Matthews Corp., W. N., St. Louis
Metropolitan Device Corp., Brooklyn, N. Y.
*Knife*
Electric Controller & Mfg. Co., Cleveland
General Electric Co., Schenectady
Matthews Corp., W. N., St. Louis
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
*Oil*
Condit Electrical Mfg. Corp., Boston
General Electric Co., Schenectady
Pacific Elec. Mfg. Corp., San Francisco
Roller-Smith Co., New York
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
*Remote Control*
Condit Electrical Mfg. Corp., Boston
General Electric Co., Schenectady
Roller-Smith Co., New York
Rowan Controller Co., Baltimore, Md.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

**TELEPHONE CONNECTORS**
Kearney Corp., Jas. R., St. Louis

**TERMINAL BLOCKS**
Burke Electric Co., Erie, Pa.

**TESTING LABORATORIES**
Electrical Testing Labs., New York

**TOWERS, TRANSMISSION**
American Bridge Co., New York

**TRANSFORMERS**
Allis-Chalmers Mfg. Co., Milwaukee
American Transformer Co., Newark, N. J.
Electric Service Co., Cincinnati
Ferranti, Ltd., Hollinwood, England
Ferranti, Inc., New York
Ferranti Electric, Ltd., Toronto, Ont.
General Electric Co., Schenectady
Kuhlman Electric Co., Bay City, Mich.
Moloney Electric Co., St. Louis
Sangamo Electric Co., Springfield, Ill.
Wagner Electric Corp., St. Louis
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
*Factory*
American Transformer Co., Newark, N. J.
Kuhlman Electric Co., Bay City, Mich.
Moloney Electric Co., St. Louis
Wagner Electric Corp., St. Louis
*Furnace*
Allis-Chalmers Mfg. Co., Milwaukee
American Transformer Co., Newark, N. J.
Moloney Electric Co., St. Louis
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
*Metering*
American Transformer Co., Newark, N. J.
Ferranti, Ltd., Hollinwood, England
Ferranti, Inc., New York
Ferranti Electric, Ltd., Toronto, Ont.
Roller-Smith Co., New York
Sangamo Electric Co., Springfield, Ill.
*Radio*
American Transformer Co., Newark, N. J.
Ferranti, Ltd., Hollinwood, England
Ferranti Inc., New York
Ferranti Electric, Ltd., Toronto, Ont.
*Street Lighting*
Kuhlman Electric Co., Bay City, Mich.

**TRANSFORMERS, USED**
Electric Service Co., Cincinnati

**TROLLEY LINE MATERIALS**
General Electric Co., Schenectady
Ohio Brass Co., Mansfield, O.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

**TURBINES, HYDRAULIC**
Allis-Chalmers Mfg. Co., Milwaukee

**TURBINES, STEAM**
Allis-Chalmers Mfg. Co., Milwaukee
General Electric Co., Schenectady
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

**TURBO-GENERATORS**
Allis-Chalmers Mfg. Co., Milwaukee
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

**VALVE CONTROL, ELECTRIC**
Bristol Company, The, Waterbury, Conn.

**VALVES, BRASS**
*Gas, Water, Steam*
Ohio Brass Co., Mansfield, O.

**VARNISHES, INSULATING**
General Electric Co., Bridgeport, Conn.
Mica Insulator Co., New York
Minerallac Electric Co., Chicago
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

**WASHERS, LOCK**
Shakeproof Lock Washer Co., Chicago

**WELDING MACHINES, ELECTRIC**
Burke Electric Co., Erie, Pa.
General Electric Co., Schenectady
Ohio Brass Co., Mansfield, O.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

**WELDING WIRES & RODS**
Aluminum Co. of America, Pittsburgh
American Steel & Wire Co., Chicago
Ohio Brass Co., Mansfield, O.

**WIRES AND CABLES and A. C. S. R.**
*Aluminum*
Aluminum Co. of America, Pittsburgh
*Armored Cable*
American Steel & Wire Co., Chicago
Belden Mfg. Co., Chicago
General Electric Co., Schenectady
Kerite Ins. Wire & Cable Co., New York
Okonite Company, The, Passaic, N. J.
Roebling's Sons Co., John A., Trenton, N. J.
Simplex Wire & Cable Co., Boston
Standard Underground Cable Co., Perth Amboy, N. J.
Western Electric Co., All Principal Cities
*Asbestos Covered*
American Steel & Wire Co., Chicago
Belden Mfg. Co., Chicago
General Electric Co., Schenectady
Rockbestos Products Corp., New Haven, Conn.
*Asbestos, Varnished Cambric*
Rockbestos Products Corp., New Haven, Conn.
*Automotive*
American Steel & Wire Co., Chicago
Belden Mfg. Co., Chicago
General Electric Co., Schenectady
Kerite Ins. Wire & Cable Co., New York
Roebling's Sons Co., John A., Trenton, N. J.
Simplex Wire & Cable Co., Boston
Western Electric Co., All Principal Cities

**WIRES AND CABLES—*Continued***
*Bare Copper*
American Steel & Wire Co., Chicago
Anaconda Wire & Cable Co., New York
Belden Mfg. Co., Chicago
Roebling's Sons Co., John A., Trenton, N. J.
Standard Underground Cable Co., Perth Amboy, N. J.
Western Electric Co., All Principal Cities
*Copper Clad*
Belden Mfg. Co., Chicago
Western Electric Co., All Principal Cities
*Copperweld*
Copperweld Steel Co., Glassport, Pa.
Standard Underground Cable Co., Perth Amboy, N. J.
*Flexible Cord*
American Steel & Wire Co., Chicago
Belden Mfg. Co., Chicago
General Electric Co., Schenectady
Okonite Company, The, Passaic, N. J.
Roebling's Sons Co., John A., Trenton, N. J.
Simplex Wire & Cable Co., Boston
Standard Underground Cable Co., Perth Amboy, N. J.
*Flexible Cord, (Heater) Asbestos Insulated*
Rockbestos Products Corp., New Haven, Conn.
*Heavy Duty Cord*
American Steel & Wire Co., Chicago
Belden Mfg. Co., Chicago
Okonite Company, The, Passaic, N. J.
Safety Cable Company, New York
Simplex Wire & Cable Co., Boston
*Fuse*
Aluminum Co. of America, Pittsburgh
American Steel & Wire Co., Chicago
General Electric Co., Schenectady
Roebling's Sons Co., John A., Trenton, N. J.
*Lead Covered (Paper and Varnished Cambric Insulated)*
American Steel & Wire Co., Chicago
Anaconda Wire & Cable Co., New York
General Electric Co., Schenectady
Kerite Ins. Wire & Cable Co., New York
Okonite Company, The, Passaic, N. J.
Okonite-Callender Cable Co., The, Inc., Passaic, N. J.
Roebling's Sons Co., John A., Trenton, N. J.
Safety Cable Company, New York
Simplex Wire & Cable Co., Boston
Standard Underground Cable Co., Perth Amboy, N. J.
Western Electric Co., All Principal Cities
*Leads, Asbestos Insulated*
Rockbestos Products Corp., New Haven, Conn.
*Magnet*
Aluminum Co. of America, Pittsburgh
American Steel & Wire Co., Chicago
Anaconda Wire & Cable Co., New York
Belden Mfg. Co., Chicago
General Electric Co., Schenectady
Roebling's Sons Co., John A., Trenton, N. J.
Western Electric Co., All Principal Cities
*Magnet, Asbestos Insulated*
Rockbestos Products Corp., New Haven, Conn.
*Rubber Insulated*
American Steel & Wire Co., Chicago
Belden Mfg. Co., Chicago
General Electric Co., Schenectady
Kerite Ins. Wire & Cable Co., New York
Okonite Company, The, Passaic, N. J.
Roebling's Sons Co., John A., Trenton, N. J.
Safety Cable Company, New York
Simplex Wire & Cable Co., Boston
Standard Underground Cable Co., Perth Amboy, N. J.
Western Electric Co., All Principal Cities
*Switchboard, Asbestos Insulated*
Rockbestos Products Corp., New Haven, Conn.
*Tree Wire*
Okonite Company, The, Passaic, N. J.
Roebling's Sons Co., John A., Trenton, N. J.
Simplex Wire & Cable Co., Boston
Standard Underground Cable Co., Perth Amboy, N. J.
*Trolley*
American Steel & Wire Co., Chicago
Anaconda Wire & Cable Co., New York
Copperweld Steel Co., Glassport, Pa.
Roebling's Sons Co., John A., Trenton, N. J.
Standard Underground Cable Co., Perth Amboy, N. J.
Western Electric Co., All Principal Cities
*Weatherproof*
American Steel & Wire Co., Chicago
Anaconda Wire & Cable Co., New York
Copperweld Steel Co., Glassport, Pa.
General Electric Co., Schenectady
Kerite Ins. Wire & Cable Co., New York
Okonite Company, The, Passaic, N. J.
Roebling's Sons Co., John A., Trenton, N. J.
Simplex Wire & Cable Co., Boston
Standard Underground Cable Co., Perth Amboy, N. J.
Western Electric Co., All Principal Cities

**WOOD RESIN**
Hercules Powder Co., Wilmington, Del.

**ZINC**
St. Joseph Lead Co., New York

THE CONVENTION HEADQUARTERS

# ROYAL YORK HOTEL

## TORONTO, ONTARIO

THE ROYAL YORK HOTEL of Toronto, Canada, owned and operated by the Canadian Pacific Railway Company, is the tallest and largest hostelry in the British Empire.

The Royal York has a convention floor entirely for convention purposes, containing a Concert Hall with stage, orchestra pit and the finest Cassavant organ in America, a Ball Room and Banquet Room with a combined banquet seating capacity for approximately 4000. The hotel has 1156 guest rooms each with private bath and shower.

A Roof Garden, beautifully decorated, large and spacious, occupies the twenty-third story of the hotel. Here during the summer months are held the famous supper dances with the incomparable Fred Culley and his renowned dance orchestra officiating.

Within twenty-five minutes drive of the hotel is the Royal York Hotel Golf Club, located in the beautiful Humber Valley. This championship 18 hole course, 6600 yards in length, was officially opened on May 19 of this year. It is acknowledged to be the finest test of golf in the Dominion.

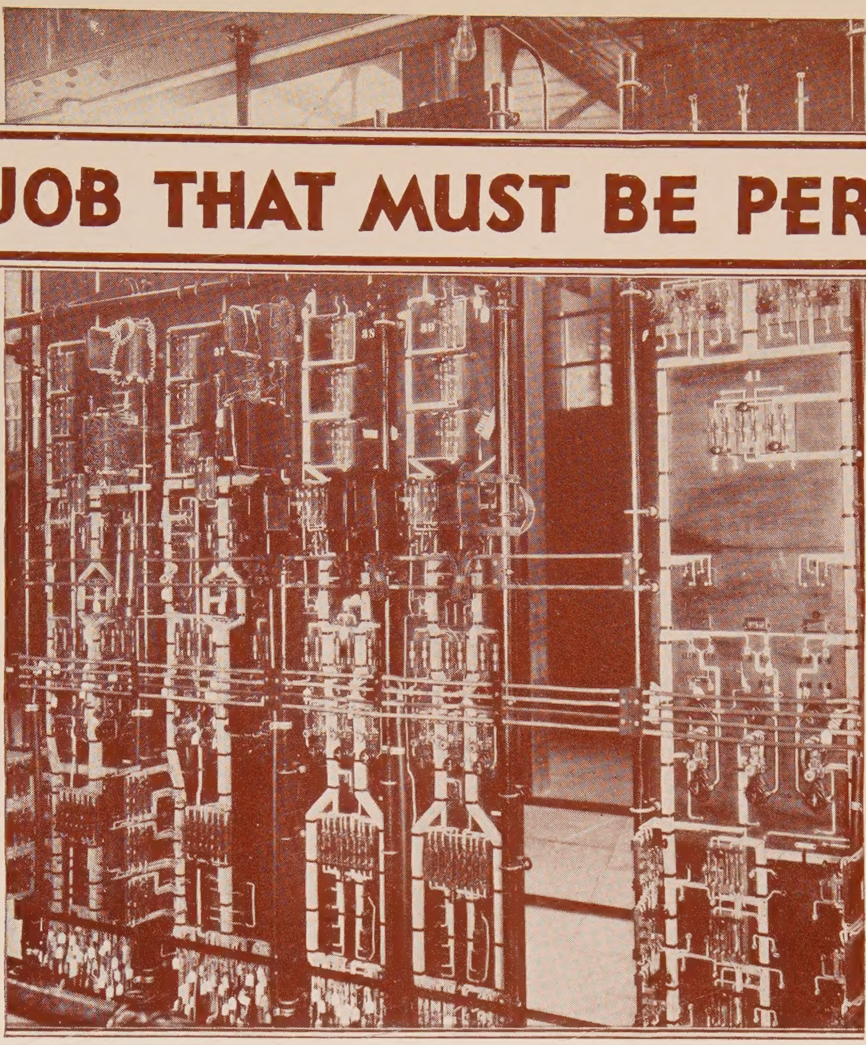
## A. I. E. E. SUMMER CONVENTION — JUNE 23-27

## ALPHABETICAL LIST OF ADVERTISERS



(For classified list of Advertisers see pages 52, 54 and 56)

# THE JOB THAT MUST BE PERFECT

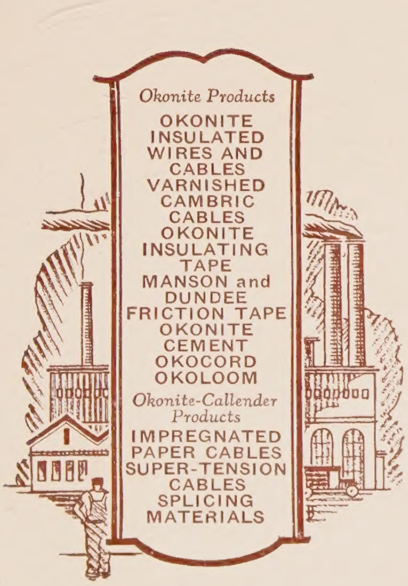


EVERYTHING about Control Cables, the quality of the cables themselves and the details of their installation must be perfect.

Control Cables are a very vital part of an electric plant because these small wires often govern the operation of whole systems. Their failure may cause serious interruptions by the non-operation of relays or the accidental closing of tripping circuits.

Okonite Control Cables have been developed in many years of extensive, specialized experience. They are made for all applications; with rubber or varnished cambric insulation, with any color scheme of braid, and with any protective coverings.

Our Engineering Service is always available on any cable problems: Station, Underground, Aerial, or Submarine.

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Founded 1878

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